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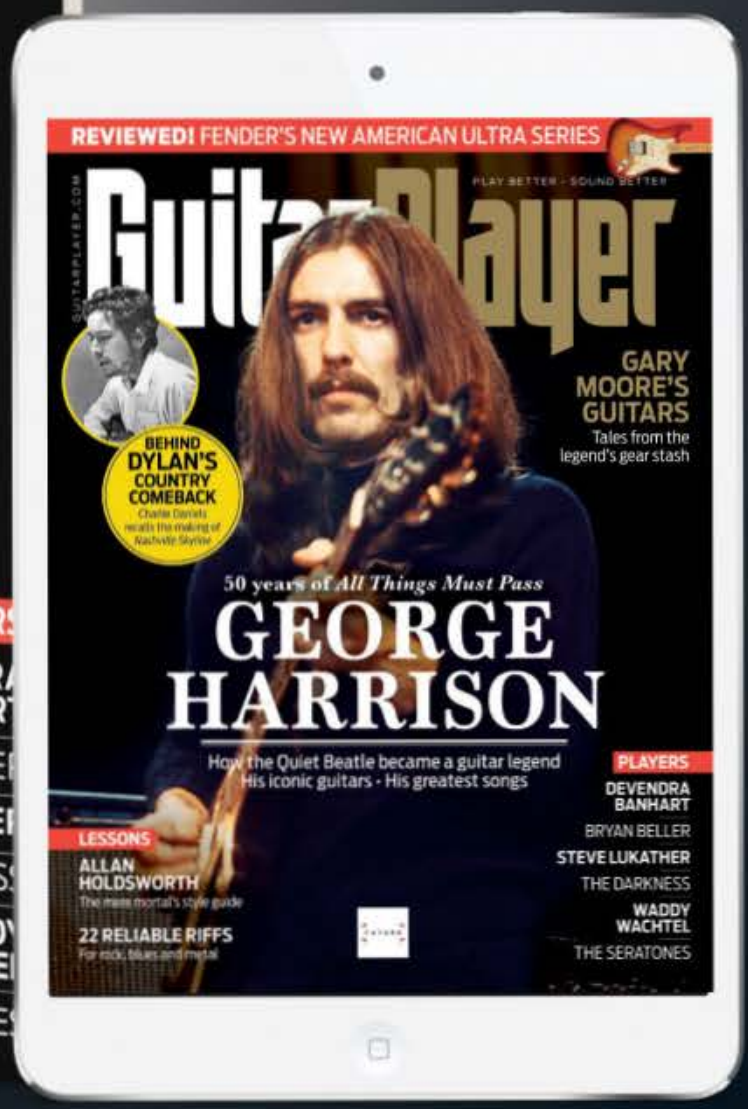

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Alan Dexter

A SIGN OF THINGS TO COME

SURPRISES ARE RARE in the tech world. So much needs to be up and running for modern silicon to be manufactured, that major breakthroughs coming from leftfield are almost unheard of. Still, knowing how something is made and comprehending the underlying technology is one thing, but whether the hardware delivers on the promise is often another.

Take the arrival of Intel's Xe graphics processors—we know they're coming, we know how the three GPUs will be configured in terms of core counts, and can even guess at some of the features on offer, but we don't know how they will perform in the real world. We'll hazard a guess that they'll probably be able to play *Crysis*, but how about the latest games? We'll have to wait and see how that plays out. We're hopeful, though, if only because having more competition in the graphics processing market wouldn't hurt, and Intel has been in the discrete GPU market before, so knows some of the pitfalls.

This issue we take a look at what else will be released over the next 12 months, from processors to graphics cards, and from screens to storage (turn to page 25 to see our predictions). We've seen some impressive advances in the last year, so the bar is set high already, but we suspect that the increased competition in the core markets could produce some promising technologies.

Technology can certainly deliver on its promises, too. By way of example, we look at AMD's Threadripper 3970X this issue. AMD's Zen 2 architecture has impressed us in its more mainstream guise, but it feels as though the high-end Threadripper, with 32 cores and 64 threads, support for PCIe 4.0, and high base and boost clocks, is a real glimpse of the future. Intel may be adamant that we don't need so many threads, but for anyone who is forced to wait on their computer to crunch numbers, this CPU is the stuff of dreams.

Hand in hand with our tech preview is our look at the games that will be released in 2020. Despite numerous predictions about its imminent death over the years, the PC continues to be the best platform for the vast majority of games, and now that the current consoles, and indeed the next-gen systems from Sony and Microsoft, are little more than tweaked custom PCs, we don't see this changing soon. There are some great games on the way, so no matter how you like to relax, there's something exciting coming your way.

On top of that, we have our usual great array of tutorials, starting with a look at how to get up and running with the free, yet powerful, Kdenlive non-linear video editor. We also show you the best way of ripping audio from a variety of sources, walk you through emulating one of the best-selling machines of all time, the Commodore 64, and also show first-time builders how to piece together a capable machine. If you, or someone you know, have never built a machine before, this is a great introduction.

Enjoy the issue!

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Open-Source Smart Home

Major players join forces to get into your home

AMAZON, APPLE, GOOGLE, and the ZigBee Alliance have joined up to form Project Connected Home over IP (CHIP), with the aim of developing a framework for the integrated smart home. The ZigBee Alliance was formed in 2002; its main work until now was to look after the ZigBee standard of low-power radio and personal area networks—the kind of gear the smart home needs. (The name is from the dance honeybees do when returning to the hive, if you were wondering.)

This new organization has a simple enough goal: to produce a standard open-source, royalty-free, certified Internet protocol for the smart home. There is a mess of standards at the moment—most gear uses a proprietary system, and so is tethered to a home network using dedicated proxies and translators. The plan is that ultimately you'll be able to use almost any devices seamlessly; your smart speaker will work with all your other smart devices, from the lighting to the security alarms, heating, and so forth, regardless of who made them.

The new protocol won't replace existing standards—this is no Wi-Fi or Ethernet rival—but rather it will work alongside existing protocols to make sure they co-operate at a fundamental level. It won't standardize user interfaces or suchlike, only the communication between devices. It will initially concentrate on Amazon's Alexa Smart Home, Google's Weave, Apple's HomeKit, and ZigBee's Dotdot. The organization's webpage gives little away; it doesn't even appear to have a logo yet. It says that "the project is built around a shared belief that smart home devices should be secure, reliable, and seamless to use." It stresses the security aspect, claiming it is a "fundamental design tenet" of the new standards. Given the number of recent breaches, that's comforting.

Good news? Yes. The current patchwork of systems is frustrating, and a standard is an obvious step forward. It won't matter which smart speaker you buy, they should all work. The smart home is a huge growth area. The smart speaker market has grown from just under 114 million units sold in 2018, to over 205 million last year, and is still growing rapidly. Smart lighting was worth a little under $8 billion in 2018, and is predicted to grow at over 20 percent a year. It's a similar story with other sectors; every graph shows a strong upward curve. The Internet of Things is arriving quickly. Now we have an organization to ensure co-operation, it's a wonder we didn't have one earlier. Initially, the winners are likely to be Amazon and Google. Apple has a few hundred devices for its HomeKit; Google has over 10,000 smart home compatible devices; Amazon has over 80,000.

Amazon has over 80,000 Alexa-compatible devices, from the useful to the pointless.

It's easy to be cynical, so let's do that: Big companies only co-operate when they think the outcome, and therefore profits, will be better. Witness Apple and Qualcomm. The two were at each other's throats over 5G patents, with billion-dollar lawsuits flying about. The spat lasted over a year, and must have consumed a fortune in lawyer's fees. Then, suddenly, peace reigned. The two shook hands, and settled everything remarkably quickly. Why? Because Apple needed the 5G chips as Intel pulled out of the market, and Qualcomm wanted a big customer. Amazon and Google are not exactly good friends, but commercial reality trumps everything.

The goal of CHIP is to help the growth of the smart home market, and fragmentation doesn't help anybody. Last year, 530 million smart home devices were shipped; it has been estimated that the figure will rise to 1.6 billion by 2024, so there will be plenty of pie to go around. As well as making money from selling hardware and subscriptions, the smart home market is going to be a data-collecting gold mine; marketing data is valuable stuff, witness the profits Facebook has made. That's a whole different issue, though.

The first draft of the Project CHIP standard is due before the end of the year. It is expected to concentrate on Wi-Fi, up to Wi-Fi 6, and Bluetooth Low Energy. Ethernet and cellular specifications will follow that. In a few years, the majority of smart home gear will be fully compatible with the new standard, and we'll have half-forgotten that there was a time when it wasn't so. **–CL**

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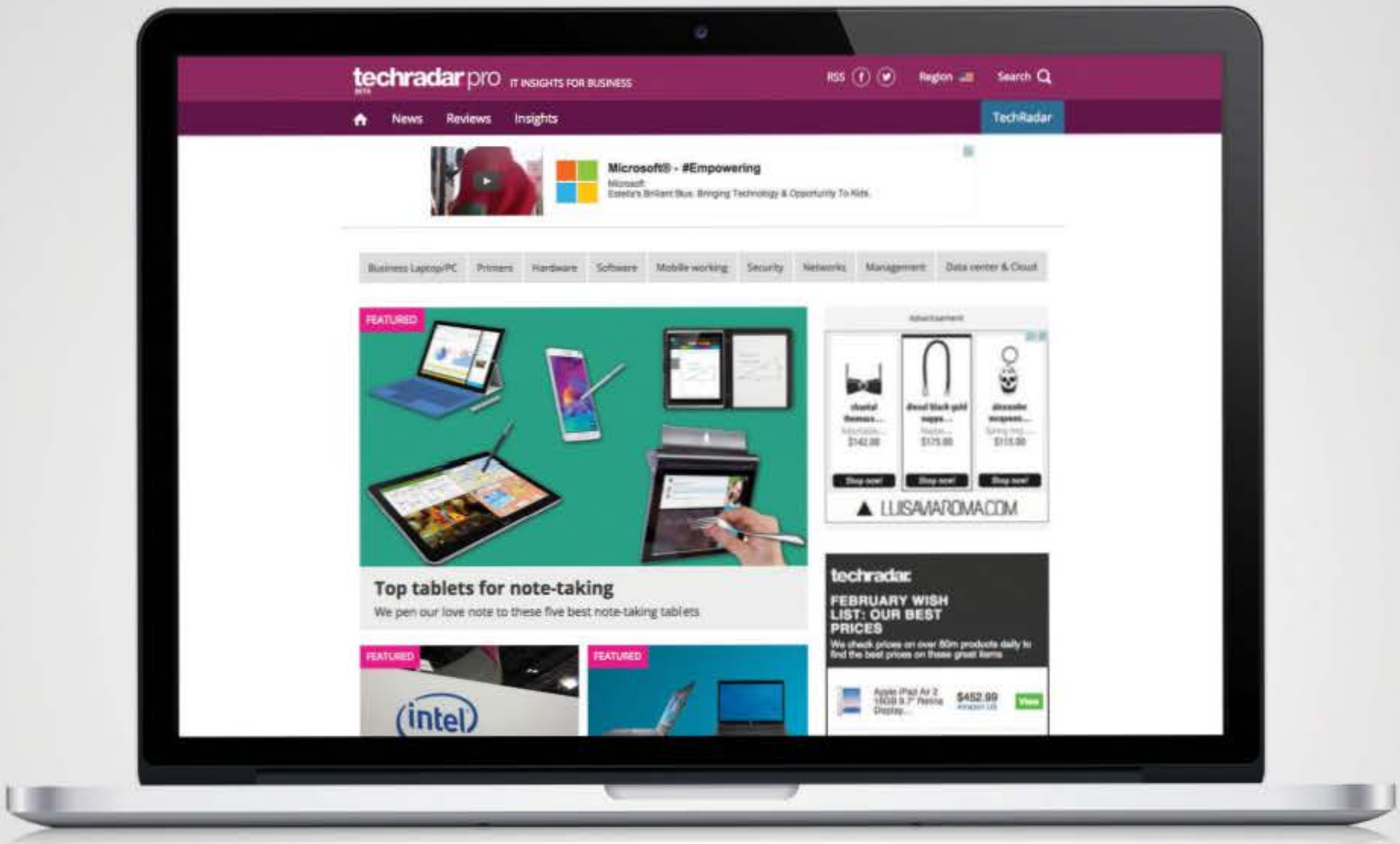

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ANYONE READY FOR CCPA?

Personal data protection law now in force

ON THE FIRST DAY of the year, the California Consumer Privacy Act came into effect, and it looks as though almost nobody is ready. At least there is a six-month grace period before enforcement begins in earnest. The law applies to all companies serving California residents that have an annual revenue of $25 million or more, or have personal data on 50,000 people or more, or that earn more than half their revenue from the sale of personal data. Being based in California is not a requirement; it's where your customers are.

The law states that any consumer can request to see any information a company has collected on them, and a list of all third parties that this data has been passed on to. It also gives the right for individuals to sue if the privacy rules are violated, not just the regulators. There must be a clear link on websites that provides the option to opt out of data sharing, and you can ask for any data collected to be deleted. There are numerous fines, some on a per consumer level, which can become highly punitive.

The definition of personal data is very wide: It covers virtually everything, down to recording a purchase you've made, what webpages you've viewed, and even data that provides an insight into psychological trends. Just collating this data, if it has been requested, can be a mammoth task, as it could be spread across multiple systems, in multiple formats. The bill was put together in a week, and it suffers from this. This is the first US legislation to give consumers protection of their personal data. Can we expect a slew of litigation?

Other state legislators are watching this carefully; something similar is anticipated in every state eventually. However, it is expected to take a year or more before the full implications of the CCPA are felt. Some people are probably happy, though: IT guys. There is going to be a lot of work to do on making systems compliant. **–CL**

TWITTER ACCOUNT HIJACK

BUG LEFT ACCOUNTS VULNERABLE

IF YOU ARE RUNNING TWITTER with automatic updates disabled, you might like to review that policy. Just before the holidays, it emerged that a flaw in the system left it vulnerable to hackers. It was possible to access people's accounts, and even post content masquerading as the victim. Twitter said that the attack was "complicated," which is something, at least. However, the rewards were high: As well as hijacking an account, it revealed private messages. The flaw has been patched now and Twitter has directly contacted people who may have been vulnerable. There is no evidence that the bug has been exploited, which is just as well—one malicious Tweet from a high-profile account could cause chaos. One thing is clear: They may be annoying, but auto-updates are there for a good reason. **–CL**

SONOS DELIBERATELY BRICKS HARDWARE

Trade-up scheme kills older speakers

SONOS HAS COME under fire thanks to its profligate upgrade tactics, which stop your speakers from working. Sonos started a trade-up program in October, where you can get a 30 percent discount if you promise to recycle your old speakers. All good so far. However, if you check to see if your speaker is eligible, and signal that you wish to trade up, it triggers Recycle Mode. This gives you 21 days before your speakers are rendered inoperable. Before then you have to redeem your discount, order a new system, and wipe your old one. You can't sell it or give it away—it is dead. After that it's up to you to dispose of it, preferably recycling it locally, although Sonos has said you can send speakers back to it for disposal using prepaid shipping labels.

Sonos says that "taking your device to a local certified e-recycling facility is the most environmentally friendly means of disposal." Yes, recycling something that is no longer useful is good, but destroying perfectly usable hardware to help you sell more new stuff hardly seems "friendly" at all. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

INTEL BUYS HABANA LABS
$2 billion invested in the Israeli maker of specialized AI processors.

APPLE AUDIO
New Apple patent is all about virtual positioning of audio, using cross-talk canceling to shift the apparent source of sound.

WITCHER 3 BOOMS
Netflix series *The Witcher* has caused a spike in the four-year-old game's popularity, seeing a 93 percent jump in players.

TRAGEDIES

LYFT BANS "DICK"
In an effort to remove genuinely offensive user names, Lyft has asked a number of people to stop using their real names.

AMAZON RING HACKED
Thousands of account details leaked, leading to unauthorized access of live feeds.

NO ESCOOTERS FOR NY
State's Governor vetoed a bill to legalize electric scooters and bikes, citing safety concerns, such as the lack of helmets.

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TSMC Reveals Its 5nm Progress

AT THIS YEAR'S IEEE IEDM (Institute of Electrical and Electronics Engineers International Electron Devices Meeting), TSMC presented a paper on its work on the 5nm process. It uses more layers—over 10, as opposed to five on 7nm. The data density rises from just short of 100 million per mm^2 with 7nm, to over 177 million. Power consumption is down 30 percent, and speed up by 15 percent. TSMC has made a test 256Mb SRAM chip, with a yield of about 80 percent, although commercial production is expected to be lower. Volume production of commercial silicon is scheduled for the first half of this year, so we will see 5nm chips in hardware before the end of the year.

The company has plans to increase its capital investment this year to over $14 billion. Manufacturing at this scale isn't cheap; a single lithography machine costs $100 million. Much of this investment is to boost 7nm production capacity, but the first major customer for 5nm silicon looks likely to be Apple with its iPhone 12.

Samsung also has plans for 5nm. The only other company currently capable of going so small, it employs the same extreme ultraviolet lithography technology as TSMC. It boasts a 10 percent bump in speed, using 20 percent less power. It also plans to have chips ready for market this year. Speculation has it that the Galaxy S11 will be the first device to use Samsung's 5nm. There are plans for 3nm, although this will require new fabrication technologies, such as nanosheet FET, which are still in the development stage. Meanwhile, Intel is still making 14nm processors.... **–CL**

TSMC's 5nm production line is ready to roll.

Instagram AI to Warn of Offense

When you post an image or video on Instagram, you may be confronted by a message informing you that your caption is similar to others that have been reported as bullying. The system is powered by AI, and has been trained using a set of data that has already been classified as offensive. It doesn't stop you from posting what you've composed; the idea is that the warning will give people the chance to "pause and reconsider their words." People are wonderfully inventive, though, so there are myriad ways to insult that this system won't catch. Online bullying does cause a great deal of unhappiness, particularly among the young, so here's hoping this might help, even if just a bit. **–CL**

Russia Tests Its Own Internet

The Russian Ministry of Communication has reportedly tested a national version of the Internet, known as Runet. It works in a similar way to systems in China, Iran, and Saudi Arabia, by controlling the points of access to the wider Internet. The state could cut or regulate these as required, effectively turning the Internet in Russia into a giant intranet, with all traffic held inside its borders. VPNs won't work, as they have no access to outside servers. The state-owned Tass news agency said that the test has assessed the ability of Runet to resist "external negative influences." Russia also has plans for its own version of Wikipedia, and laws that ban the sale of phones that don't have Russian software installed. **–CL**

TOTAL IMMERSION

For those who want the coolest PC possible

FORGET LOTS OF NOISY FANS, forget liquid CPU or GPU coolers. The king of keeping cool is total immersion. Yes, put the entire workings of your rig into liquid. New Hampshire-based CoolBitts specializes in such systems, and has just released the ICEbox5-Sys-1—everything you need to dunk your PC. The tank is effectively your PC case, complete with motherboard tray, and rear I/O. panel. There's a power meter, radiator with fans, and a pump. You also get quite a lot of coolant—obviously, this has to be a dielectric; in this case, it is five gallons of EC-120, a synthetic single-phase coolant specifically designed for electronics. This is better than mineral oil, which has featured in other immersion systems. It is easier to handle, doesn't get things growing in it (yuck), and is kinder on the pumps—although it doesn't come cheap. The rear I/O is kept out of the liquid, but pretty much everything else goes in. This means the whole lot gets cooled, not just the hot spots. The system can manage thermal loads of up to 750W, and can keep both CPU and GPU at a fairly frosty 30 C. The system is monitored via a PCI card, so you can keep an eye on all the vitals. Immersion systems have been used in commercial servers for a while, where the savings on expensive air conditioning systems can be considerable; they became particularly popular when mining cryptocurrency took off. There have been few home-brew systems, but CoolBitts clearly thinks there may be a home market, too. The price? $2,450. The coolant alone costs about $500. It is wonderfully over the top, but your rig will be very cool. **–CL**

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Jarred Walton

TECH TALK

The Death of Multi-GPU Support in Gaming

ONCE YOU BUY the fastest hardware currently available, what do you do if it's still not fast enough? That's a question we explore with Dream Machine, pushing beyond the limits of what's reasonable, and trying to build the most bodacious system possible. Every recent iteration of Dream Machine has doubled down on the graphics cards—sometimes even quadrupling down.

If you have a pile of money burning a hole in your pocket, I want to let you in on a secret: Multi-GPU PCs are a dying breed, and have been for years.

Even at the height of the multi-GPU craze, getting everything to run well was a crapshoot. Two-way SLI or CrossFire might improve performance in about half of the big games, three-way would help a few of those, and four-way was basically for 3DMark and a handful of games. Nvidia began downplaying anything beyond two-way SLI with its Pascal GPUs—there were ways to get three-way SLI support, but it wasn't worth the hassle. With Turing, Nvidia officially killed off anything more than two-way SLI with its NVLink connector. AMD has likewise said little about CrossFire lately; it still exists, but almost no new games support it.

What's the deal? A 2080 Ti with over twice as many cores is up to twice as fast as an RTX 2060, so why can't two 2060 GPUs match that? Even with NVLink, the co-ordination of resources between GPUs happens over a comparatively slow bus. The 2080 Ti has 616GB/s of local bandwidth, while NVLink tops out at 100GB/s. All that background synching gets messy and slows things down.

Game engines are also becoming increasingly complex, and real-time lighting, shadows, and other effects require additional work. CPU and system bottlenecks show up in many games, even with the fastest CPUs. Throw in a second GPU, and a game can end up with reduced performance.

An even more egregious example of how dead multi-GPU is for gaming is games with ray tracing. At maximum quality, especially at 4K, even a Titan RTX is likely to struggle, and that's only with one or two ray-tracing effects. Unfortunately, no games with ray tracing even try to support more than one GPU. I'm not sure it's even possible—theoretically it is, if a developer puts in the work, but it's definitely impractical.

Even for games that technically support SLI, the results often aren't good.

Even when a game tries to support dual GPUs, the results often come up short. Two recent examples are *Red Dead Redemption 2* and *Star Wars: Jedi Fallen Order.* Using a Core i9-9900KS with a pair of RTX 2080 Ti cards and an NVLink connector, I gave both a shot at maxed-out settings and 1440p/4K.

Average frame rates improved in *Star Wars* at 4K (not at 1440p), but minimum fps didn't. However, when playing the game, SLI caused massive stutters, sometimes lasting several seconds, and more frequently in combat—the worst time for that sort of behavior. Yuck.

Red Dead Redemption 2 was better in some ways, worse in others. There was lots of flickering initially, but restarting mostly fixed that. Performance at 1440p and 4K maximum quality improved by about 50 percent, but stutters and stability were more common. This is arguably the best case for multi-GPU now, and it still isn't great.

Rather than trying to max out settings and resolution with SLI or CrossFire, I find it's best to just tweak some settings and run with a single fast GPU. You might not set any benchmark records, but you'll spend more time gaming and less time fiddling and arguing with hardware. But I admit my SLI setup is an excellent space heater.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

Excellent Open-Source Tools for Road Warriors

WHEN TRAVELING OR SIMPLY WORKING in a local coffee shop, how secure is your Internet connection? Often, these access points are open and unencrypted, introducing security risks to smartphones and laptops. There are a few ways to mitigate these risks and preserve privacy in a world that is increasingly saturated with wireless devices and snoopers.

Playing with local network security and privacy tools is one of those weird hobbies that can eat up hours on weekends or late nights. There are plenty of open-source tools one can use to secure a home network. Using advanced firewall operating systems, such as pfSense or DD-WRT, enables you to create customized network and security policies. Domain name service (DNS) apps, such as Pi-Hole, allow the network to deny access to ad services and trackers at the DNS level. However, once you leave your home, those tools disappear.

There are several tools you can employ while on the road to preserve privacy. The first is to use a virtual private network (VPN) to encrypt the traffic from your device to the VPN server. While commercial VPN offerings may provide a level of anonymity, a VPN server hosted on a home server or a small virtual private server (like those offered by Digital Ocean, Amazon AWS, or Google Cloud) provide the ability to add security without the level of anonymity. By using Docker or system packages, you can set up an OpenVPN or Wireguard server in an afternoon.

When it comes to reducing advertisements or trackers, it is possible to use Pi-Hole on the go as well. While it can be more difficult to use on your cell phone, your laptop can be protected with Pi-Hole by running the service in a Docker container. I've done this for months, and have enjoyed improved browsing speed, even while roaming around on public Wi-Fi networks.

> A travel router has the ability to be the only Wi-Fi connection your devices need to use.

While advertising is the primary income source for a lot of websites and online services, the network load required to serve those ads can hobble browsing speed when on public or hotel Wi-Fi, which often leaves much to be desired as-is. By blocking the serving of ads at the DNS level, you can reduce the data required to successfully load every webpage you visit. The result is a faster browsing experience, and more efficient working when away from home or the office.

While both Pi-Hole and a VPN are incredibly useful, I had to wonder: Is there something better?

I recently bought a GL.iNet GL-AR750S travel router. The AR750S is a small router that can treat a public Wi-Fi connection as a WAN connection, and broadcast its own SSID for a local LAN for your devices. In addition, the AR750S runs on a build of OpenWRT, a Linux-based fork of DD-WRT. Plus, this router is small enough to fit in your pocket, and takes a micro-USB 2.0 input for power (like a Raspberry Pi).

The utility of a travel router is large, but not obvious at first. With a travel router, you can enjoy the protection of a firewall for all the devices you use with it. Additionally, you can have the router function as a VPN client, encrypting all the traffic from your devices through a VPN tunnel. You can even use a USB 3G/4G LTE cellular dongle for mobile Internet. But in my view, the biggest advantage is the ability for the travel router to be the only Wi-Fi connection your devices need to use. When moving from network to network, you need only log into the new Wi-Fi connection from one device, through the router's web administration interface. All your devices—phone, laptop, Chromecast, and whatnot—can consistently rely on a single set of network policies and resources.

While I haven't managed to get the Adblock plugin to work as designed, the VPN and Wi-Fi capabilities of a small travel router have me convinced that such devices are great accessories for the working traveler.

Top: **The GL.iNet GL-AR750S is a pocket-sized OpenWRT router.**

Alex Campbell is a Linux geek who enjoys learning about computer security.

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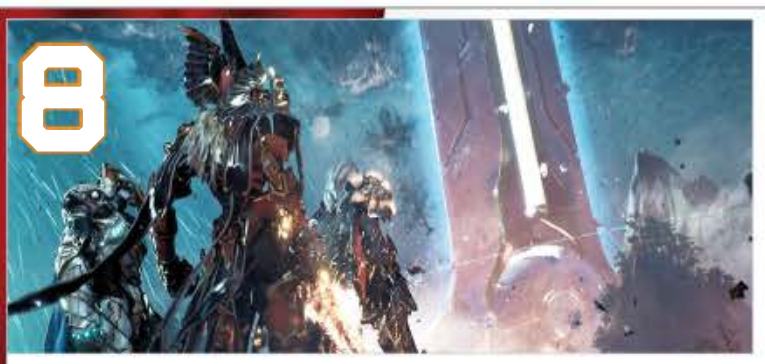
THE LIST

BEST REVEALS FROM THE GAME AWARDS 2019



GODFALL "Looter-slasher" *Godfall* is a co-op third-person action title from Counterplay Games, *Duelyst's* developer. Expect weighty combat and bulky armor.

GEARS TACTICS *Gears of War* meets *XCOM.* It was announced a while ago, but gameplay footage and a release date—April 28, 2020—put it in the limelight.

THE ELDER SCROLLS ONLINE: SKYRIM Todd Howard's refusal to let *Skyrim* die is almost admirable, with a new *ESO* expansion coming in 2020.

D&D: DARK ALLIANCE A GoPro-esque trailer saw four D&D types hacking, slashing, and casting spells in the wintery wasteland of this action-RPG.

MAGIC: LEGENDS *Magic: The Gathering* is finally getting a game that isn't card-based. It's an open-world MMO with real-time combat.

WEIRD WEST Two ex-Arkane bosses teamed up with Devolver Digital to bring us this gloriously creepy top-down adventure in the American West.

THE WOLF AMONG US 2 LCG Entertainment bought Telltale Games' assets, so we can look forward to a sequel to Bigby Wolf's dark fantasy adventures.

SENUA'S SAGA: HELLBLADE II A follow-up to 2017's *Senua's Sacrifice,* this looks to be an angrier, darker game than its ponderous predecessor.

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HEAD TO

BY **CHRISTIAN GUYTON**

Threadripper 3970X vs. Core i9-10980XE vs. Ryzen 9 3950X

Last month we looked at affordable APUs; this time, we're going in the opposite direction, and pitting the biggest and baddest CPUs around against each other. These are the high-end desktop parts, the big boys, the costly but high-powered processors that many of us will never even hold in our hands. These CPUs have more cores, higher clock speeds, and monstrous power draws compared to your average desktop processor, making short work of CPU-heavy tasks and benchmarks. But which one is best? Let's take a look.

ROUND 1

Value

Which of these HEDT processors is the best value? Well, it's not the new Threadripper. Yes, the 3970X has some entertainingly over-the-top specs and tends to top most benchmarking tables, but if you thought the second-gen Threadrippers were pricey, do not look up the 3970X on Amazon. The other two processors are pretty close in price, with the Ryzen 9 3950X costing $900, and the Core i9-10980XE coming in at $1,050.

In terms of value for money, they're pretty close, too. The 10980XE is 16.7 percent more expensive, but it does have 12.5 percent more cores (that's 18 cores compared to the Ryzen's 16). The 3950X's cores are tad faster, though, with a core clock of 3.5GHz as opposed to the 10980XE's 3.0GHz. It's a close call, and none of these CPUs comes with an included cooler to tip the balance of value; the assumption is that if you can afford one of these chips, you can afford a powerful third-party cooling solution.

Ultimately, we'll give it to the 3950X, because it's the cheapest of the three, yet can still outperform the Intel chip in some areas. The Ryzen CPU still comes with a free game and three months' worth of Xbox Game Pass for PC at the time of writing, too.

Winner: Ryzen 9 3950X

ROUND 2

Efficiency

Again, the Threadripper stumbles out of the gate and has to be put down. Tragic. Yes, that monstrous 280W thermal power design means that the 3970X is out of the running, as it guzzles power to ensure that top-tier performance. The Threadripper series has always demanded serious cooling, too, requiring a specific TR4-compatible cooling block.

The Ryzen 9 3950X has a relatively conservative TDP of 105W; still pretty high for a conventional desktop CPU, but sensible for an HEDT part. There's nothing particularly notable efficiency-wise here, but none of these CPUs is very efficient, all demanding a lot of power and producing a lot of heat, particularly if overclocked. The i9-10980XE draws 165W, and uses the more esoteric LGA 2066 socket in terms of cooling, unlike the 3950X, which uses the common AM4 socket.

In short, the Ryzen is the winner again here. The 3950X isn't amazingly efficient by any means, but it's certainly the best in this limited field, almost purely by virtue of its comparatively low power draw. It's relatively overclockable, but doing so brings its thermals up into the range of the other two CPUs, so this is a close one, but we'll give it to the Ryzen.

Winner: Ryzen 9 3950X

ROUND 3

Features

The Intel CPU isn't looking good in this section. There's a handful of features unique to each of these processors, but both AMD chips have something that the 10980XE lacks: PCIe 4.0 support. Intel has yet to break into the fourth generation of PCIe devices, which brings support for super-speedy NVMe Gen 4 M.2 SSDs, and improved bandwidth for expansion components, such as GPUs. Specialist systems, such as home RAID setups, benefit significantly from the improved read/write headroom PCIe 4.0 offers, and anyone who deals with large file transfers on the regular should see an improvement, too. Both AMD chips utilize PCIe 4.0 for core interfacing, improving internal speeds.

PCIe 4.0 is the big draw, but there are other features of note. Intel's Turbo Boost tech means that the 10980XE is theoretically capable of some seriously impressive automatic overclocking figures on a per-core basis—useful, as manual overclocking isn't something you'd want to do with these CPUs. The 10980XE and 3970X have quad-channel memory support, while the Ryzen 9 CPU only has dual-channel support. That leads us to look to the Threadripper for our winner this round, with PCIe 4.0 and quad-channel memory making it the most feature-packed chip on the list.

Winner: Threadripper 3970X

From left to right: **The Threadripper is by far the largest, connecting via the sTRX4 socket.**

The XE in i9-10980XE stands for "Extreme Edition." Or "Xtreme Edition," if you are still living in 2006.

Only the 3950X has pins on the chip; the others require mobos with their own pins. You need an X570 board for this.

ROUND 4

Performance

Yeah, all right, you guessed it: The Threadripper wins this round. Thirty-two cores and sixty-four threads make for an insurmountable foe, and the 3970X dominates in almost every area. The 10980XE is able to eke out a few minor victories in specific areas (it handles singlethreaded performance slightly better in a few tests), and it does provide superior performance in most games, but only by a very small margin; those frame rates are far more dependent on the GPU being used, and it's easy to hit a point of diminishing returns, because the Intel Core i9-9900KS actually beats the 10980XE in most games. More than eight or twelve cores doesn't benefit you much in gaming terms, with the 3950X actually beating its big brother, the 3970X, in some titles.

The 3950X might be the cheapest chip, but it's a surprisingly scrappy contender here. It can't match up to the core-packed power of the 3970X, but it does manage to beat the 10980XE in some areas, thanks to fast multithreaded performance. Using AMD's Ryzen Master utility software to tweak CPU performance for different tasks (such as using the Game Mode and Creator Mode options for the relevant purposes) can make a noticeable difference for both AMD processors. In the end, though, the numbers speak for themselves: Tons of cache memory and cores make the Threadripper our victor.

	Threadripper 3970X	Intel Core i9-10980XE	AMD Ryzen 9 3950X
Cinebench R15 Multithreaded (fps)	**7,573**	3,799	3,992
Cinebench R15 Singlethreaded (Index)	210	204	**213**
POV-Ray 3.7.1 (pps)	**14,754**	9,379	8,334
H.264 Handbrake (fps)	**208**	153	156
7-zip Benchmark Compress (MIPS)	**160,626**	124,447	87,628
7-zip Benchmark Decompress (MIPS)	**345,801**	153,650	179,138
VeraCrypt AES (MB/s)	19,650	**25,100**	10,300

Best scores are in bold.

Winner: Threadripper 3970X

And the Winner Is...

The best CPU in this selection is the Threadripper 3970X. There's no doubt about that; this 32-core beast wins in almost every area of testing, and has the raw processing power to outmatch the other two. The 3970X is awesome in every sense of the word, but it's fair to say that it isn't a realistic prospect for most consumers. Pricing a single component at $2,000 isn't really going to entice anyone outside the prosumer space, and while the other two processors aren't exactly affordable, there's more potential for enthusiasts there.

Unless you're carrying out very specific tasks (such as disk encryption, in the vein of the VeraCrypt benchmark), we would find it difficult to recommend the Intel Core i9-10980XE. Yes, it's the best in most game benchmarks when coupled with a 2080 Ti, but only by a few frames per second, and we really can't stress enough that you should not be looking at any of these components to build a pure gaming system. HEDT parts are best put to use in computers that will be carrying out CPU-intensive tasks, and we'd recommend close runner-up the Ryzen 9 3950X for any enthusiasts reading this. $900 is a lot for a CPU, but the 3950X is a high-quality component that will provide top-notch processor performance.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Frame Rate Boosts
> MDS Dangers
> Storage Expansion

Low WoW Frame Rates

I built a PC based on one you had in one of your issues—an AMD Ryzen Threadripper 9250X on an Asus ROG Zenith Extreme X399 mobo, with 32GB RAM, and a GeForce RTX 2080 Ti WindForce—and I can't figure out why I'm getting low FPS while standing in town in *World of Warcraft*. I get around 30–40fps in town, yet in raids I hit around 90fps, which is weird. I've installed AMD Master and have switched it to eight cores, which delivers a few more FPS, believing that *WofW's* last update, which supports multicore, would fix the issue.

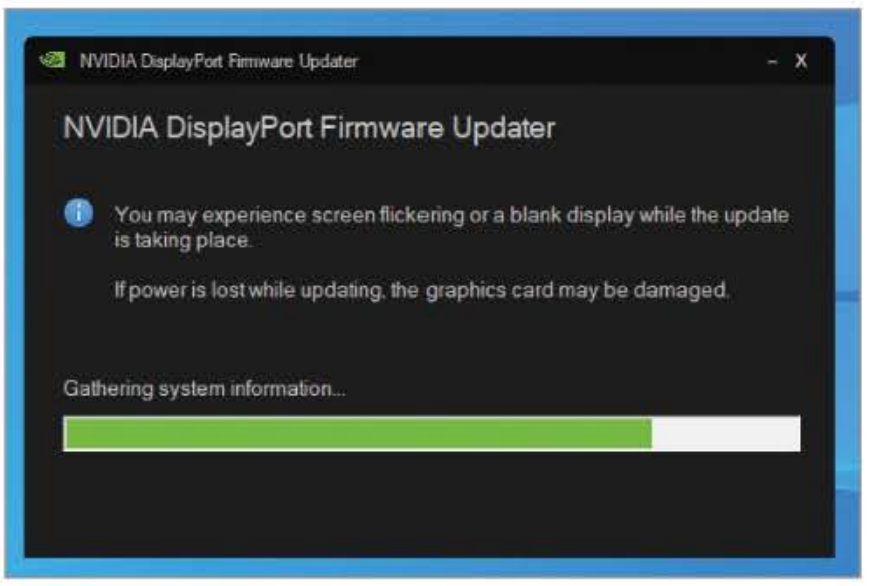
Any ideas on what is going on with my AMD build? I usually stick with Intel, but figured I'd try AMD as it's so highly rated. **–Jason Benson**

THE DOCTOR RESPONDS:

It's well known that *WoW's* age now counts against it. The engine has traditionally failed to make use of modern hardware efficiently, utilizing a single core and focusing on the CPU, rather than the GPU. The recent multicore update has improved matters, but this kind of bizarre, almost unpredictable behavior is—ironically—predictable, given the hundreds of complaints down the years.

What can you do? Not worry about your hardware setup, for starters, other than check for any BIOS updates to your Asus mobo. It has been panned by several reviewers for poor performance with non-certified RAM, but that's not the case with your four sticks of 8GB DDR-3000 RAM.

Otherwise, focus your efforts on the game. Start by making sure *WoW* and its add-ons are all updated. If the issue persists, explore the settings, and try reducing one or two preferences (including Shadows) for towns by a notch or two. Consider disabling all Deadly Boss Mods and even the ElvUI. If none of this has any effect, you may have to accept the game's limitations, because it's nothing to do with your PC.


NVIDIA DisplayPort Firmware Updater
NVIDIA DisplayPort Firmware Updater
You may experience screen flickering or a blank display while the update is taking place.
If power is lost while updating, the graphics card may be damaged.
Gathering system information...

DisplayPort issues can sometimes be fixed with a firmware update.

DisplayPort Problems

I bought a Gigabyte 1080 Ti Gaming OC 11G last November for under $640. Things have been great, but lately I've been having a problem with the monitor not being seen by the motherboard or Win 10 at startup. At first, a hard restart after the busy light calmed down would work, but now it doesn't. I removed the Gigabyte card and reinstalled my old 980 card—same problem, so I reinstalled the 1080 Ti. My Acer XB270HU display only has one DisplayPort connection, so I couldn't test it with an HDMI connection to try to pinpoint the cause. I decided to try a second monitor through the DVI, and discovered that the Acer wakes up once the desktop loads, and continues to work flawlessly if I have the second monitor connected on boot. I was wondering about the DisplayPort cable, but since there is no problem with the second monitor connected, I figured it was OK. What do you think the problem is? **–Bart Cubbage**

THE DOCTOR RESPONDS:

The "good" news is that you're not alone, Bart. We tracked down several online reports of people suffering the same problem. It appears to be down to a DisplayPort handshake issue, and keeping your second display permanently connected should continue to work.

If you want to dig deeper, there's a known bug with Nvidia's DisplayPort implementation on graphics cards sporting Maxwell or Pascal architectures, which includes your 1080 Ti. That said, it should

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↘ submit your questions to: doctor@maximumpc.com

only affect DisplayPort implementations of 1.3 or 1.4, while your XB270HU supports DisplayPort 1.2, so it's likely this isn't an issue. You can eliminate this possibility by downloading and running the Nvidia DisplayPort Firmware Updater 1.0 (www.nvidia.com/en-us/drivers/nv-uefi-update-x64), which will let you know if a firmware update for your card is required, but we suspect this is already in place. If an update is available, note the warnings before applying it—unless you plan to revert to a single display, we suggest leaving well alone.

Another way to revert to a single display would be to try an HDMI to DisplayPort cable (not DisplayPort to HDMI!), which should allow you to hook up the display to your card's HDMI port, which may also "solve" the problem.

Can't Import File

Hey Doc, I've got a problem with setting up a VPN client on my QNAP NAS 453be. I want to set up a dedicated VPN connection for the Download Station BitTorrent client, but every time I try to import an OVPN file from my VPN provider into the client portion of QVPN Service, it throws up an error claiming it's not a "regular" file. How do I get it to accept the profile file? **–Freddie Patel**

THE DOCTOR RESPONDS:
We traced this to a single underlying file, which you need to remove and replace. Any existing profiles are wiped by this step, which requires you to SSH into your NAS using a suitable client like PuTTY for Windows (www.putty.org) or a basic Terminal in Linux:

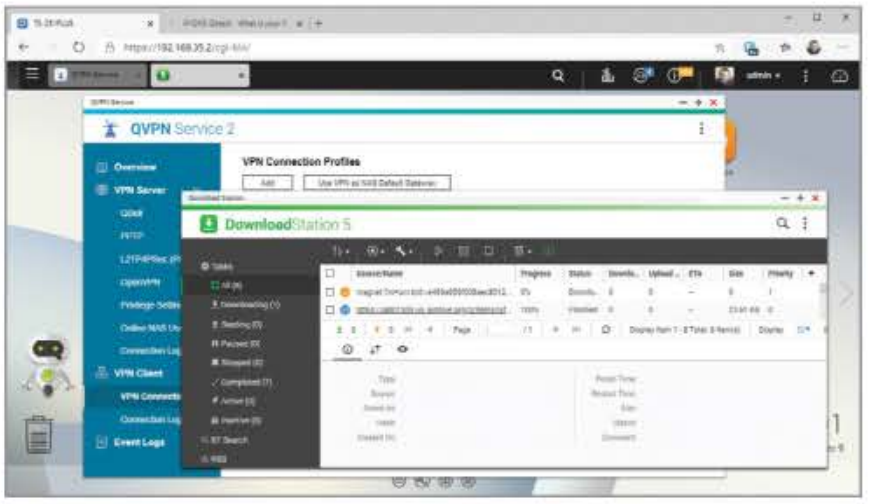
```
ssh admin@192.168.x.y
```

(substitute "192.168.x.y" with your NAS's IP address). When prompted, enter the password for your NAS's admin account, then issue the following:

```
$ rm /etc/config/ext_if.conf
$ nacli sync_ini /etc/config/ext_if.conf
```

You should now find QVPN Service accepts profile files. After you've set up the connection, click "Connect" under "Actions." Now open App Center, right-click the Download Station shortcut, and choose "Connect to → IP address of VPN" to redirect all Download Station connections through the VPN client.

To verify it's working, go to https://ipleak.net and scroll down before clicking "Activate" under "Torrent Address detection." Right-click the "This Magnet link" URL and choose "Copy," then switch to Download Station. Click the "+" button and choose "Input URL" before pasting the copied link here and clicking "Next → Apply." Switch back to the IPLeak page, and after a short pause, you should see your VPN server's IP address appear.



Mask your torrenting with QVPN Service and Download Station.

Is MDS a Problem?

Intel CPUs have been reported as having faults relating to Hyper-Threading. I have older Intel CPU systems and patching them really slows them down, so I run them unpatched. Now we have MDS attacks and are told to turn off Hyper-Threading to be safe. AMD CPUs are reported as not having as many faults due to different architecture. How serious is the problem?

–Bob Johnson

THE DOCTOR RESPONDS:
First, a primer about these vulnerabilities: To speed up processors, instructions can be run out of sequence or in parallel across different cores within the CPU. The problem arose due to a flaw in the design whereby instructions can be executed before their privileges have been verified, giving malware potential access to protected kernel memory for the purposes of stealing sensitive information.

Because the flaw is at the hardware level, patches (so-called microcode updates) can only be applied at the software level. They're not permanent, so are applied each time you start your PC, by your BIOS or Windows, depending on where the update originated. Applying these patches has a performance impact that can be noticeable—and that's before you consider the major hit you get in CPU-intensive applications, such as games, if you follow Microsoft's advice to disable Hyper-Threading.

Which brings us to what we think is your real question: "How seriously should I take this threat?" That's down to you—how important is security over performance? We always err on the side of caution, so can't recommend running unpatched CPUs, but the call to disable Hyper-Threading is less clear cut. For most home users, this is probably overkill: The microcode provides protection against known threats, but you remain vulnerable to flaws yet to be identified.

If the performance hit of running the patches is too great, perhaps there's another question: Is it time to upgrade your PC? The only real fix for these latest flaws is to change your hardware—MDS doesn't affect eighth and ninth-gen Intel models, while AMD CPUs are also unaffected.

Add New Drive to NAS

I have a Zyxel NAS-520 two-bay hard drive. I've filled a 500GB drive and have bought a 1TB drive to go alongside it. I'd like both drives to be visible as a single large drive, but I can't seem to configure the two drives this way. What do I need to do? **–Steve Ball**

THE DOCTOR RESPONDS:
As you have two drives with different capacity, you should avoid the two supported RAID (0 or 1) options in favor of JBOD (Just a Bunch Of Drives), which lets you see both drives as a single combined volume. Sadly, it sounds like your 500GB drive was configured as a Basic drive, which means the new drive will be treated as a separate volume.

If you want to combine them into a single drive, first add redundancy to your setup by plugging a 2TB external drive into the NAS. Once done, use Backup Planner to copy everything across to the USB drive. Then you can go into Storage Manager and delete both drives before recreating them as a single JBOD volume. Once done, return to Backup Planner to restore the data from your USB drive to the NAS's internal drive.

If that's not feasible, you need to try to reinitialize your newer, larger drive, choosing the JBOD option when prompted for a RAID or disk type. Do this via the web interface's Storage Manager app—select "Volume," then select the new drive under "Volume" and choose "Delete" to remove it, followed by "Create" to set it up again, this time as a JBOD disk. Then copy everything from your original disk to the new disk before deleting the old disk, then adding it to the existing JBOD volume. We still recommend investing in that backup for your backup—you never know when you might need it.

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CB CREATIVE BLOQ

“Design should be seasoned well, cook for a minute on each side, then let it rest.

MATT SMITH

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2020 TECH PREVIEW

The Maximum PC team predicts what the coming year holds for PC technology

It's been a pretty wild year for PC technology, and an even wilder decade. This was the decade that brought system building more into the mainstream, and saw PCs rise above the hubbub of consoles and mobile devices to achieve a healthy position in the market and in our hearts.

PC gaming is in a particularly good place, with multiplatform multiplayer more common, and proper gaming hardware getting cheaper. DDR4 memory exploded on to the scene, initially pricey, but now more affordable and higher quality than ever. M.2 SSD took longer to get off the ground, but now it's hard to imagine a high-end rig without one of these high-speed drives.

It's now easier than ever to build yourself a PC. Next-generation integrated graphics allow for inexpensive work systems, while GPUs have improved incrementally to enable truly next-level graphics. Ray tracing also saw a rise in popularity; while Nvidia's RTX cards arrived in 2018, it was in 2019 that the question of ray tracing was truly posed to the industry.

We've been treated—spoiled, even—with sleek, powerful hardware, and it leaves us hopeful for the coming year. 2020 promises plenty, but even more is under wraps. Next-gen CPUs and Intel's entry into the GPU market are exciting prospects, so here's our hot-off-the-press take on what will happen in the tech industry in 2020.

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GRAPHICS
CHANGING THE STATE OF PLAY

GRAPHICS ARE DUE for an exciting year. AMD and Nvidia are squaring up against each other to deliver a new generation of powerful discrete GPUs, but there's a newcomer: Intel, promising to make its GPU debut in 2020 with a new series of cards, currently named the Xe series. While we haven't seen a full lineup announcement yet, at the time of writing, we have gathered a few scraps of information. The news of Xe's existence was leaked all the way back in 2018, at which point the given code name was Arctic Sound. Intel was quick to do an official reveal, albeit one lacking any real information on the new GPUs.

Since then, Intel has fed us little bits and pieces. At CES in early 2019, it was revealed that the GPUs would be manufactured on Intel's 10nm process, confirming the suspicions of many following Xe's development. A careful look at Intel's hiring patterns in that sector shows that the chipmaker has been poaching talented individuals from AMD and Nvidia for years now, including Jim Keller, the original lead architect of AMD's Zen processor microarchitecture.

The first "proper" reveal hit in May 2019, when Intel revealed two single-fan design concepts for the Xe GPUs. This was just set dressing, though; no substantial technical details were released. However, accidentally published driver details demonstrated some possible specs for the Xe cards—specifically, three models. These included three numbers: 128, 256, and 512. The prevailing assumption is that these figures refer to the number of execution units per GPU, which can be multiplied by eight to get an estimated core count.

That leaves us with three GPUs with 1,024, 2,048, and 4,096 cores. While Intel's cores won't work in the same way as existing Nvidia technology, like CUDA, we can immediately compare these three cards to three existing GPUs in Nvidia's GeForce lineup: the GTX 1650, RTX 2060, and RTX 2080 Ti. Intel might be firing on all cylinders when it joins the GPU market, with a Xe card for 1080p, 1440p, and 4K respectively.

STAYING COMPETITIVE

If that's the case, AMD needs to hit back hard. While the RX 500 and 5000 series GPUs are effective 1080p and 1440p solutions, AMD isn't offering a high-end desktop GPU right now. The Radeon VIII might pack tons of VRAM, but it isn't competitive with the likes of the RTX 2080 Ti and 2080 Super, especially not in gaming terms. If Intel pushes a powerful, expensive GPU right out of the gate, AMD risks losing its stake in the high-end slice of the market.

Perhaps that wouldn't be such a bad thing, though. AMD's RX 580 and 590 GPUs might no longer be in production, but they're still readily available at low prices, and still hold up excellently for 1080p gaming. AMD is also pushing out plenty of new 5000-series cards, like the 5300 and 5600, with no sign of a more powerful GPU, such as a theoretical 5900 XT. If AMD decides it wants to focus on the more affordable end of the GPU spectrum, who are we to question that? Cornering the low-end market could be beneficial, and if AMD is the competitor that brings budget 1440p gaming to the masses at the most competitive price point, it might not need to worry about 4K—yet.

Nvidia, on the other hand, almost certainly will be providing a new 4K-viable—possibly even an 8K-viable—GPU in 2020. An RTX 3000 series is what we want to see, and with Intel entering the market, it's what Nvidia needs to release in order to stay relevant. It's too early to speculate on the future of the improved Super cards, but an RTX 3080 would be a great thing to see at Computex this year.

Indicators are that we'll likely see the architecture revealed at Nvidia's GPU Technology Conference in March; our opinion is that it absolutely has to use the 7nm process, likely the Ampere architecture, developed with input from Samsung and TSMC. Speculation that we'll see a major reveal at CES in January seems unlikely to us. The further down the timeline we go, the more likely a major reveal gets; Computex 2020 could well be the place for a major lineup reveal.

Performance isn't likely to be the sticking point of the RTX 3080, or any new GeForce series. It'll be pricing. There's little doubt that a 3080 or 3080 Ti (the latter of which would typically be released later, although we wouldn't be overly surprised to see an early flagship launch of the super-powered Ti model, as we did with the 2080 Ti) will have awesome performance. Improved ray tracing is all but guaranteed, but these GPUs

An early image of Intel's Xe GPU, which may not reflect the appearance of the finished product.

Above-left: **The 2080 Ti is the high-end champion of Nvidia's current-gen GPUs.** ***Above: Cyberpunk 2077*** **is one of a growing number of games that will feature ray-tracing support.**

should also show general performance boosts over the 2000-series cards in areas such as rasterization.

PRICE PANIC?

When it comes to price, though, Nvidia has a blank check and the guts to use it. When the next generation of GeForce cards hits, we fully expect to see ludicrous prices for the high-end consumer cards. An RTX 3080 Ti could very possibly sit in the vicinity of $1,500 or more, and those cards will likely still be the only ray-tracing-enabled cards on the market.

Once Intel arrives and AMD gets its own ray-tracing tech off the ground, those prices will need to drop. Improvements to the RDNA architecture (as will be seen in the newly announced Xbox Series X) means that the next generation of AMD cards will obviously be more powerful, but once ray tracing eventually hits Radeon cards, Nvidia will lose its USP and effectively be forced to lower its prices. Moving forward, we're hoping to see Nvidia bring out real competitors in the mid-range and budget fields, potentially with a card like an RTX 2660, bringing ray tracing to more affordable GPUs in the same way that AMD already plans to.

VRAM is the last big question. We can obviously expect that some of 2020's high-end cards will have crazy amounts of video memory. The 16GB Radeon VII is a year old, and we haven't seen a mainstream GPU with more memory yet (barring a few very expensive workstation cards). Perhaps the more interesting question will be how much memory the mid-range and budget cards are equipped with; 4GB is a low-end standard right now, but it's hard to imagine that will be enough to cut it in the futuristic landscape of the 2020s.

MAX QUESTIONS

Where are we with laptop GPUs? The Max-Q variants of GTX and RTX cards mean that Nvidia has the market cornered for discrete laptop graphics, retooling existing GPUs with lower thermal power design and quieter operating volumes, typically in exchange for slightly lower clock speeds.

Max-Q models of the newer Super GPUs are nowhere to be seen, although the technology is there. The Super GPUs use existing architecture, which means that adapting them for laptops should be straightforward, but they've yet to be ratified at the time or writing. There's a small chance that Nvidia will skip the Super generation for laptops, going straight for Max-Q versions of its next-generation chips.

There's no news on Intel GPUs in compact formats for laptops, and we're not prepared to speculate; news on the Xe GPUs is thin enough on the ground. AMD did have a stake in the laptop GPU game with X versions of its RX 500 series cards, but things have gone quiet on that front, too. That could be about to change, though, with AMD coming back with the 5500M and other 5000 M-series GPUs, like the 5300M, smashing similar GPUs. If AMD claims more of the market, we could see a more committed development of discrete laptop GPUs from Nvidia, rather than retooling a few of them for laptop use.

CHEAP & CHEERFUL

A recent interview with Raja Koduri, senior vice president of core and visual computing at Intel (and former AMD director of graphics architecture) revealed some potentially telling information regarding the upcoming Xe GPUs. He asserted that more expensive cards were still viable. Intel wouldn't need to sell a lot of them to turn a profit.

Koduri alluded to $500–600 cards, noting that not everybody would buy them. He argued that Intel's strategy would have to include affordable, mainstream GPUs, saying its range "even started around $100." Right now, the only GPUs at that price are either woefully underpowered, or the RX 570. The 570 is a great-value 1080p GPU, but it's without competition, and almost two years old. AMD's stock will run out, and Intel could be there to sweep in with a budget GPU for the 1080p gamer. AMD will no doubt rally with the lower end of the 5000 series, and Nvidia? We're not sure.

Team Green has been struggling at the cheaper end. The GTX 1650 was underwhelming, and while the 1650 Super performed better, it only has 4GB of VRAM, and is closer to $200. We'd like to see Nvidia remember that more people want affordable cards, and produce a budget component to its upcoming lineup.

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PROCESSORS

THE RACE FOR MORE, FASTER CORES

2019 WAS A GREAT YEAR FOR DESKTOP PROCESSORS. That was mainly thanks to advances in AMD's Ryzen line, not down to anything that Intel was up to, but to be fair, there were some headline-grabbing releases for Big Blue, too (we'll come back to that shortly). The problem for Intel is that 2020 looks like more of the same, with the company playing catch-up to what AMD has already done. Can it compete? Let's dig a little deeper to find out.

Intel's 10th-gen Comet Lake chips are the core of its desktop release strategy this year. These are expected to drop in April, essentially still based on the Skylake architecture, and using the 14nm++ production process. This means that we won't be seeing any revolutionary performance increases due to reworked fundamental design changes, but there is a good chance that we'll see tweaked performance from subtle optimizations of this well-known core.

The big sell for Comet Lake is the number of threads on offer, with the top-end chip, the Core i9-10900K, expected to ship with 10 cores and 20 threads as standard. The Core i7 CPUs will have eight cores, while the Core i5s and Core i3s will have six and four cores respectively. Importantly, all the chips in the Comet Lake family are expected to have Hyper-Threading as standard, doubling the thread count—no marketing-forced changes here, which is a nice step forward. The likes of the Core i5-10600, with six cores and 12 threads, makes for a tasty upgrade from the previous Core i5-9600, for example, especially if the pricing is maintained (however doubtful that is).

Now for the bad news: These new 10th-gen chips will use a new LGA1200 socket, which is the same size as the outgoing LGA1151 socket—so hopefully your CPU cooler should be compatible, even if you do have to buy a new Z490 motherboard. We assume these new pins are needed for the updated core count at the top end, but Intel isn't opposed to subtle tweaks here and there to ensure that its chips aren't backward compatible.

We don't have anything firm in terms of speeds yet, although Intel has shown that it can push this microarchitecture hard, even on the 14nm process. The Core i9-9900KS, which was launched at the end of October 2019, has a base clock of 4GHz (up from 3.4GHz on the 9900K), along with an all-core turbo of 5GHz. It may be an older process, but Intel's 14nm++ architecture is clearly a known entity and it's doing some impressive work. We can expect a subtle uptick on performance against the existing

Zen 3 is due, and will use TSMC's 7nm+ production process.

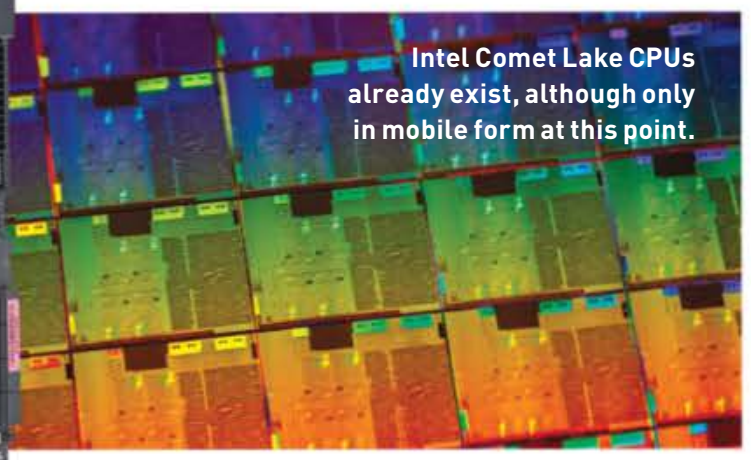
ARMING AN ALTERNATE FUTURE

ARM has been threatening to take the fight to Intel and AMD for years, and at the end of 2019, we finally saw this take serious shape in the form of the Microsoft Surface Pro X. While not the first time we've seen a Qualcomm-powered solution running Windows, the fact that it came from Microsoft means this probably isn't just a flash in the pan.

The Surface Pro X uses a newly developed processor, the SQ1, that Microsoft co-developed with Qualcomm. This ARM-based chip has an impressively low power draw of just 7W, yet offers three times the performance per watt of the Surface Pro 6. The problem is, 64-bit apps don't currently work with this chip unless they've been recompiled for it; 32-bit apps should work, but apps that call on other services, some of which may have 64-bit dependencies, can undermine this. Most apps and games have not been ported across, though, and you'll find that there are a lot of things that don't currently run. Dropping $1,000 on a machine that doesn't run your favorite app can be a problem, but it's early days, and Microsoft will hopefully be able to iron out the problems.

This shift to ARM is something that we expect to see more of going forward. While this initial effort from Microsoft is somewhat faltering, it does show an intention to take ownership of the core of its machines—something Apple has been doing with its iPads for some time, with its latest Bionic A12X knocking up comparable numbers to mid-range chips. There is still an expectation that Apple will shift over to a chip of its own creation in its Mac range too.

The good news for Zen 3 is that it's going to be compatible with existing AM4 motherboards.



Intel Comet Lake CPUs already exist, although only in mobile form at this point.

The Core i9-9900KS proved that there is still life in the aging 14nm++ process.

ninth-gen processors, with bigger improvements anticipated at the top of the stack.

One thing we don't know at this point is when we'll see something new on the integrated graphics front. We've been impressed by Intel's Iris Plus graphics subsystem, as seen in its mobile Ice Lake chips, but this won't make it to Comet Lake. Intel has tended to push serious gamers toward discrete graphics solutions on the desktop, but there are plenty of uses where integrated is all that's needed. Now we have a fairly established GPU-less set of chips from Intel (chips with the F suffix), it may be that it charges a premium for Iris Plus.

It's worth bearing in mind that while AMD may be winning all the plaudits for general computer work, Intel is still the go-to manufacturer when it comes to pure gaming—there may not be much of a lead, but a few frames' difference here is all that hardened gamers need to warrant their preference. Will this still be the case with Comet Lake? Probably, especially if Intel can keep pushing up the operating frequencies.

APU ANNOUNCEMENTS

Before Intel gets its Comet Lake game going, AMD is expected to show off its Ryzen 4000 Renoir APUs, possibly at CES. These are designed for laptops, an area where AMD has traditionally struggled, and where Intel still holds court. Ryzen 4000 APUs are based on the Zen 2 cores, as opposed to the Zen+ used by Ryzen 3000 APUs, which means they'll have support for PCIe 4.0, as well as improved memory support, and better overall performance.

What about the graphics core? We've been eagerly awaiting the Navi architecture to make its debut in APUs, but it looks as though we're going to have to keep holding our breath on this front, because these new chips are expected to use Vega still. AMD is, of course, producing the chips that will power Microsoft and Sony's next-gen consoles, and they are both expected to employ second-gen Navi cores, so it may be some time before such chips appear in a PC-friendly guise.

What about Zen 3? Dr. Lisa Su, AMD CEO and president, had some good news on this front in a recent interview with VentureBeat: "We're well underway with Zen 3 as a follow-on, as well, for 2020." Understood to use Extreme UltraViolet Lithography to improve transistor density and reduce power consumption, the process, which AMD is referring to as 7nm+, produces an improvement to IPC over Zen 2 of 15 percent on average.

Unlike Intel, AMD is sticking to its existing platform for Zen 3, with its AM4 socket remaining compatible for these new chips. AMD isn't expected to make any changes on this front until Zen 4 drops, some time in 2021.

WHATEVER HAPPENED TO DDR5?

DDR5: Where did it go? The original blueprints for the next stage of RAM were published by the Joint Electron Device Engineering Council way back in 2017, and while JEDEC had hoped to have the standard for DDR5 released for public use by 2018, as of the time of writing, the details are still being finalized.

The potential performance increases offered by DDR5 are significant. Lower voltage requirements and increased memory speed are some of the improvements here, along with the addition of onboard voltage regulators within each DIMM stick. This would mean that motherboards would no longer require their own voltage regulators for the memory subsystem, although what this means for motherboard and RAM pricing is unclear right now.

Some manufacturers have been eager to show off their early DDR5 models, including Rambus and SK Hynix, but news has been thin on the ground since then. SK Hynix did reveal a fully functioning 6,400MT/s chip in early 2019, but that sort of product seems nowhere near ready to enter the consumer market.

Our prediction is that we'll likely see DDR5 components hit professional servers first, with the reduced voltage being a huge benefit for large-scale server farms. That lower power draw will likely also be attractive for mobile devices, but whether DDR5 will hit those before conventional desktop parts is anyone's guess.

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STORAGE MORE SPACE, FASTER DRIVES, ALL FOR LESS MONEY

WHITHER Z-NAND AND OPTANE? This will be a key question in 2020 for solid-state storage. Z-NAND and Optane are respectively Samsung and Intel's next-gen persistent memory technologies, intended to improve upon conventional flash memory. Both are already available, but they're expensive, and arguably don't quite deliver on the lofty expectations created by marketing pitches.

Intel will release its second-gen Optane tech in 2020 and it looks like a zinger. Code-named Alder Stream when applied to SSDs, as opposed to memory DIMMs, where Optane is also implemented, Intel claims three times the IOPs performance for its second-gen Optane tech, and slightly lower latency. Arguably, it's IOPs performance and latency, rather than peak data throughput, that make the biggest difference to how fast PCs feel on a day-to-day basis. So, improvements in those areas are exciting.

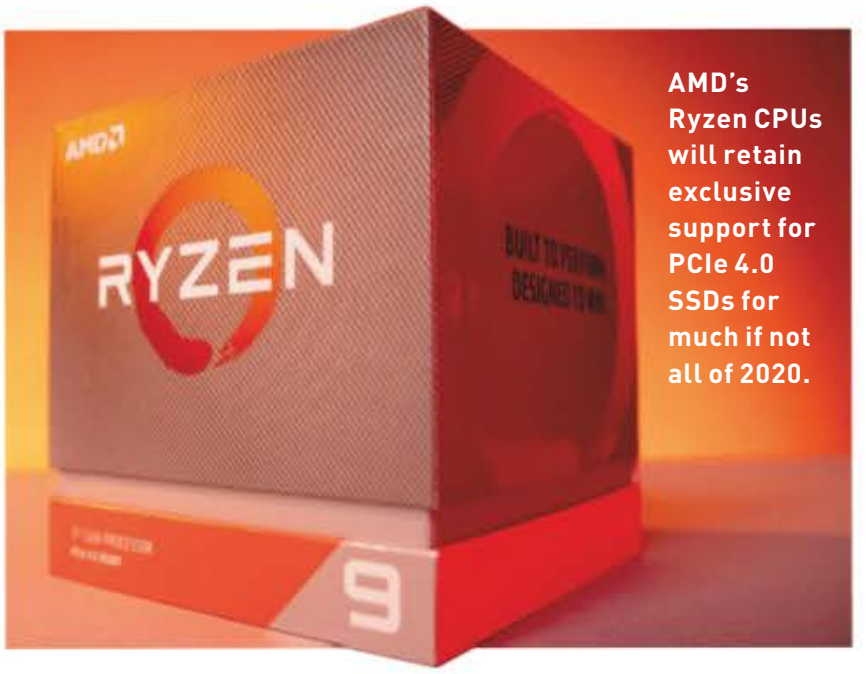
Less clear is whether Optane pricing will come down enough to make it more viable for mainstream PC users. Right now, the cheapest Optane SSD for consumers costs nearly $200, and offers a measly 118GB of storage. Larger and newer models are even expensive. Here's hoping 2020 is the year Optane gets affordable. As for Samsung's Z-NAND, the company is keeping quiet about plans for a new generation of its low-latency persistent memory tech. For now, it has yet to push Z-NAND into the consumer space, and shows no sign of doing so in 2020, more's the pity.

EXPRESS DELIVERY

The other big story in 2020 will be more widespread adoption of the PCI Express 4.0 interface. The immediate snag facing this bandwidth upgrade, which doubles peak transfer speeds compared to PCIe 3.0 to 2GB/s, is platform support. Only AMD offers native PCIe 4.0 support with its desktop CPUs; Intel CPUs only support PCIe 3.0. In fact, last summer, Intel even published marketing material to "prove" PCIe 4.0 doesn't matter for gamers.

It's not a huge surprise, therefore, to learn Intel's next family of desktop CPUs, Comet Lake, will not support PCIe 4.0, particularly when you consider that Comet Lake is yet another 14nm respin of its existing architecture that dates back to Skylake in 2015, rather than being based on the new 10nm node and the Ice Lake design.

At the very earliest, you're looking at late 2020 and Intel's first 10nm desktop processors, code-named Tiger Lake, for Intel to bring PCIe 4.0 support to consumers. Of course, PCIe 4.0 only improves raw bandwidth. While the prospect of up to 8GB/s of throughput is exciting, it does nothing for IOPs and random access performance. Moreover, the underlying performance of the TLC and QLC NAND chips in a typically affordable SSD can't get near the performance of a quad-lane PCIe 3.0 interface, let alone PCIe 4.0. So, the whole notion is rather academic except for the most expensive drives based on ultra-quick memory chips. All of that is perhaps why SSDs with PCIe 4.0 support have been slow to come to market, and have all been based on the same Phison controller chipset. Intel, very likely, isn't going to ship consumer SSDs with PCIe 4.0, for instance, until it has a desktop platform that supports them. The other big players have limited motivation, too, given how few PCs with PCIe 4.0 support exist. Samsung has yet to announce PCIe 4.0 SSDs aimed at consumers, for instance, restricting its offerings to the enterprise market for now. Long story short, if you want to make the most of any PCIe 4.0 SSD in 2020, you're going to need an AMD platform in your PC. And your choice of SSD models will probably remain fairly limited.



AMD's Ryzen CPUs will retain exclusive support for PCIe 4.0 SSDs for much if not all of 2020.

DENSITY DIRECTION

Still, there's more to storage than speed. What about data density? 2019 saw QLC or quad-level NAND flash memory push SSD prices down. In 2020, PLC or penta-level NAND flash that can store five bits of data in each memory cell might hit the market. Both Intel and Toshiba have detailed plans for PLC memory.

If PLC for 2020 is an unknown, what's certain is TLC and QLC memory based on stacked or 3D technology with higher layer counts and thus improved storage density. Intel, for instance, is aiming for 144-layer QLC flash memory in 2020. Samsung is already producing NAND flash with 100 layers. To put that into context, Samsung's 860 QVO drive uses 64-layer QLC NAND memory, as does Intel's 660P. A 1TB 860 QVO can be had for just over $100 today. More than doubling the number of layers, in Intel's case at least, implies a cost per GB of less than half that of today's QLC drives. In other words, big SSDs are going to get a lot cheaper in 2020. We've been talking about it for a long time, but 2020 looks like it will truly be the year of mass solid-state storage. A 4TB SSD for $150 in 2020? It's certainly possible.

SCREENS THE YEAR HIGH REFRESH GOES MAINSTREAM?

WILL 2020 BE THE YEAR OLED TECH finally makes the leap from HDTVs to the PC? Save for one exception, very likely not. OLED technology is already becoming more available in laptops, and that trend will continue. But desktop PC monitors? Not so much.

In fact, we're not totally convinced that's ever going to happen on a significant scale. Instead, we suspect the desktop PC monitor market may skip OLED and jump straight to micro LED, whose superior stability lends itself far better to PC apps, which tend to have persistent interface elements, like the Windows taskbar.

Problem is, micro LED is still in the R&D and very early commercialization phase. It's not coming to mainstream TVs in 2020, let alone monitors. What you can expect is improvement of LCD tech. Earlier in 2019, LG rolled out the first IPS monitor with a claimed 1ms response time. Faster response means the ability to combine the superior colors and viewing angles of IPS with the speed that used to be the preserve of TN panels. Expect 1ms IPS monitors to become more widespread in 2020.

REFRESHING NEWS

Of course, faster response is key to another aspect of monitor performance, namely refresh rates. PC monitors currently peak at 240Hz, while Asus recently announced a laptop with a 300Hz display. However, we're not expecting the latter to become the norm in 2020. That's because the returns diminish as the refresh rate rises. There's already some debate over the real-world benefits of 240Hz versus 144Hz for most PC users. Whatever your take, the benefits of going beyond 240Hz are very slim indeed.

That said, what you can expect in 2020 is 120Hz-plus monitors becoming more affordable, and for high refresh to transition into a mainstream and professional feature, not just for gamers. Already, Acer is selling pro-grade monitors with 144Hz refresh, demonstrating that it, at least, views high refresh as something non-gamers will appreciate.

HDR support will continue to improve and become more commonplace, too. In 2019, one of the big LCD panel makers, AU Optronics, announced a 32-inch 4K mini LED panel. The key advantage of mini LED is the number of local dimming zones it enables. The AU 32-inch panel offers 1,152 zones. That compares to the 300–500 zones typically seen in existing monitors with local dimming. That AU Optronics panel has just found its way into the new Asus ProArt PA32UCX.

Meanwhile, arguably the world's leading maker of quality IPS panels for PC monitors, LG, is planning a new panel with over 2,000 zones for late 2020, at which point the halo effect suffered by existing local-dimming monitors running in HDR mode should be well and truly sorted. While mini LED isn't exactly going to become the norm in 2020, we do hope to see more monitors with mini LED backlights, and thus more precise local dimming.

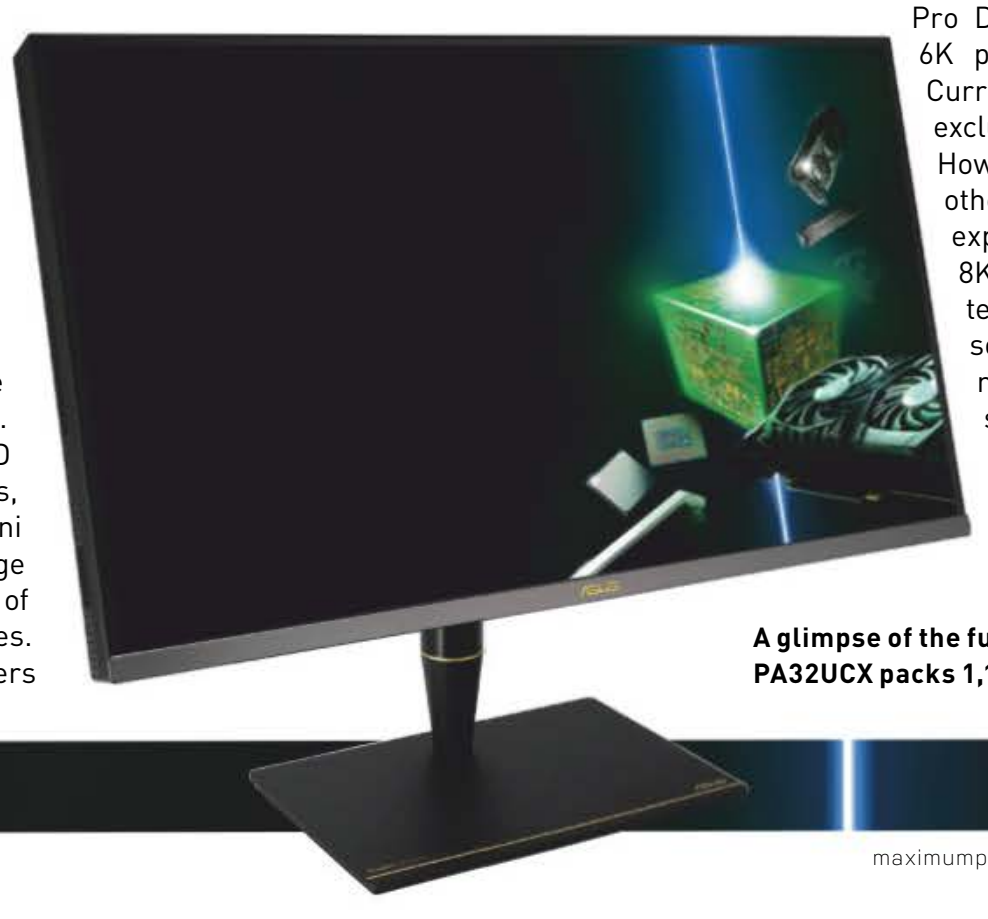
AU Optronics is also working on new VA panels with 240Hz in 30 and 32-inch sizes, adding another option for those who enjoy the improved contrast and saturation of VA tech. These VA panels might well become favorites for gamers.

SLIM CHANCE

Monitors that combine all of the above—higher refresh rates plus mini LED tech—will also appear in 2020. AU Optronics has a 32-inch 4K panel with 144Hz and local dimming in the works that should finally appear in 2020. Another trend for 2020 will be even slimmer bezels. LG is developing a new technology known as Oxide that delivers "real borderless" panels.

Elsewhere, we're hoping that USB Type-C docking support will come down in price and become more widely available in 2020. Once you've connected a laptop to a monitor with a single cable for driving the display, charging, and connecting peripherals, you do not want to go back to an old-school multi-cable solution.

However, what we're sadly not expecting in 2020 is much progress when it comes to resolutions and pixel density. Apple's Pro Display HDR uses a 32-inch 6K panel manufactured by LG. Currently, it's unclear if Apple has exclusive access to that panel. However, even if it does appear in other monitors, it will be a very expensive option. Meanwhile, 8K TV tech is still years away in terms of mainstream adoption, so the prospect of cheap 8K monitors adapted from TV sets isn't going to happen in 2020. In short, affordable monitors beyond 4K are unlikely to be a reality in 2020, which is a pity.



A glimpse of the future: The Asus ProArt PA32UCX packs 1,152 local dimming zones.

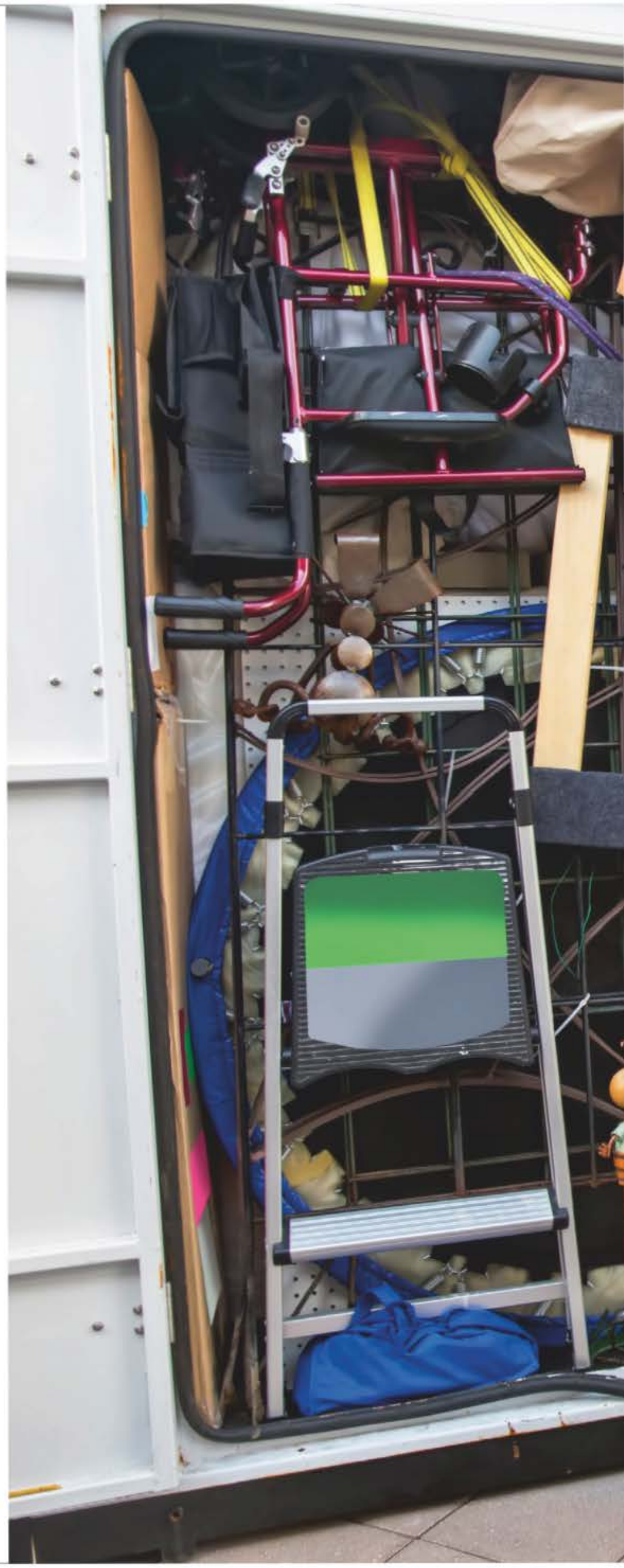
FREE UP SPACE

How can you ensure your PC doesn't run out of storage? *Nick Peers* has some pointers...

"YOU HAVE RUN OUT OF DISK SPACE." There it is, unequivocal. It wasn't that long ago that Windows started popping up "You are running out of disk space" messages, swiftly followed by "You are running very low on disk space." No matter, the day has finally arrived. Your hard drive has finally run out of space, and now you have to do something about it. The question is: What?

These days, running out of disk space should be impossible. With terabytes of storage available to you, how do you manage to fill it all up? One reason might be that you don't actually have terabytes to start with—perhaps you're using a laptop that only came with 128GB, or a two-in-one tablet whose 32GB is barely enough to fit Windows on, never mind any apps or data.

Don't panic, though, because over the next few pages, we show you everything you need to know to solve the problem. You'll learn to spot the early warning signs, plus take steps to keep your hard drive as clean as possible. We also examine ways to add extra capacity, enabling you to move your data off your boot drive to free up space. And if all else fails, we show you how to upgrade your PC's boot drive, plus migrate everything from the old to the new drive. It's all here, so turn the page to solve your disk space issues.



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MONITOR YOUR DRIVE SPACE

Find how what happens when you run out of free space, and how to keep an eye on how much is left

THAT WARNING WE FLAGGED in the intro is unlikely to be the first indication you get that you're running out of space. It's not designed to appear until you have 200MB or less free—a drop in the ocean these days. Instead, Windows' first warning is likely to appear when you open File Explorer to the "This PC" view to see your drive's usage is represented by a red bar, rather than a blue one. This appears when your drive has less than 10 percent of its space left, although the seriousness of the warning does depend on the size of the drive. For example, a 64GB drive with under 6GB left is more worrying than a 2TB drive with 180GB free.

MORE DRIVE ALERTS

Windows Update also throws up an alert if it discovers there's insufficient room to install the latest updates—this usually appears when you don't have secondary storage attached to your PC for it to use as temporary storage. It can pop up when there's as much as 11GB still free on your drive for major updates, but of more concern is if it shows when you're trying to install a cumulative update, which indicates your drive has less than 3GB left.

All PCs make use of small recovery partitions (anywhere from 500MB to 8GB). Sometimes, these partitions are assigned drive letters in Windows—often in error. Because they're designed to store specific files and nothing else, they can be filled almost to capacity, resulting in Windows throwing up a low space disk warning.

The solution is simple: Type "disk" into the Search box and click "Create and format hard disk partitions." Locate your Recovery partition in the list, then right-click it, and choose "Change Drive Letter and Paths." Click "Remove" followed by "Yes" at the warning, and finally "OK." Bingo—no more warnings for that drive.

MONITOR DISK USAGE

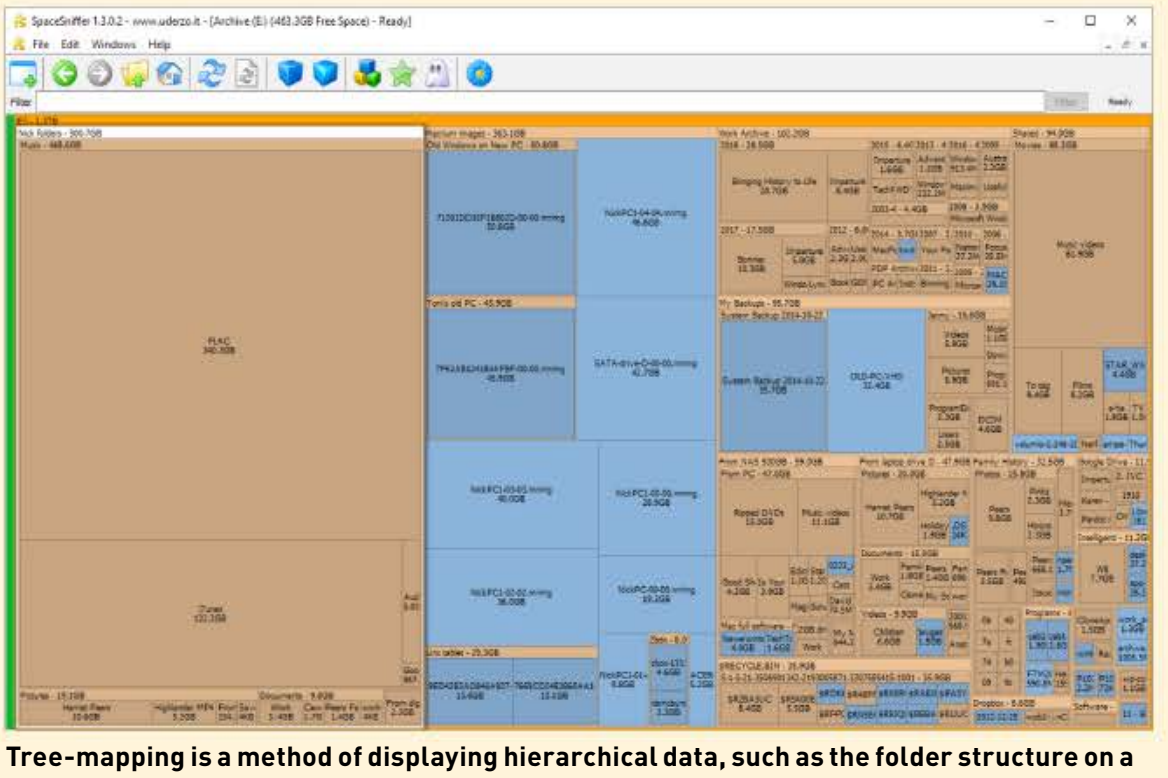
It's all very well knowing that your free space is disappearing, but what's actually taking up all that room? Your first stop on the quest for knowledge should be Windows' own tools: Navigate to "Settings → System → Storage," and after a short while, Windows reveals what types of file are taking up the most space on your system drive. You'll see categories for "Apps & features" and "Temporary files," and you can click "Show more categories" for a more precise listing of usage by categories as varied as "Mail," "Documents," and "Videos."

Click an entry in the list, and you're able to not just view more detail, but take remedial action. For example, if your Temporary files are gobbling gigabytes of space, click this to manually clean them up—note, the Temp setting now covers files stored in your "Downloads" folder, although they are excluded by default. As you'll see over the page, you should make use of Windows' new Storage Sense feature to manage this automatically, removing temporary files as required to

A DIFFERENT VIEW

If you don't like WinDirStat, and are looking for a different approach to viewing your drive's make-up, try SpaceSniffer (www.uderzo.it/main_products/space_sniffer). It has a more modern user interface, but more importantly provides a visual view that helps you identify which folders contain the most files. Again, be sure to run it as an administrator. Unlike WinDirStat, you must focus a view on one drive at a time, but thanks to its labeling system, it's easier to spot which folders contain the most data, as they're clearly named, and their file size listed. Simply double-click one to zoom in to view its contents, or double-click its parent folder (displayed above it) to zoom back out.

If you know which files are likely to take up most space, use the "Filter" box to input a file type (such as *.mp4) and click "Filter" to focus on that. Right-clicking a displayed folder brings up the File Explorer context menu, enabling you to delete unwanted files.



Tree-mapping is a method of displaying hierarchical data, such as the folder structure on a large hard drive, in a logical way, making it easy for a human to understand.

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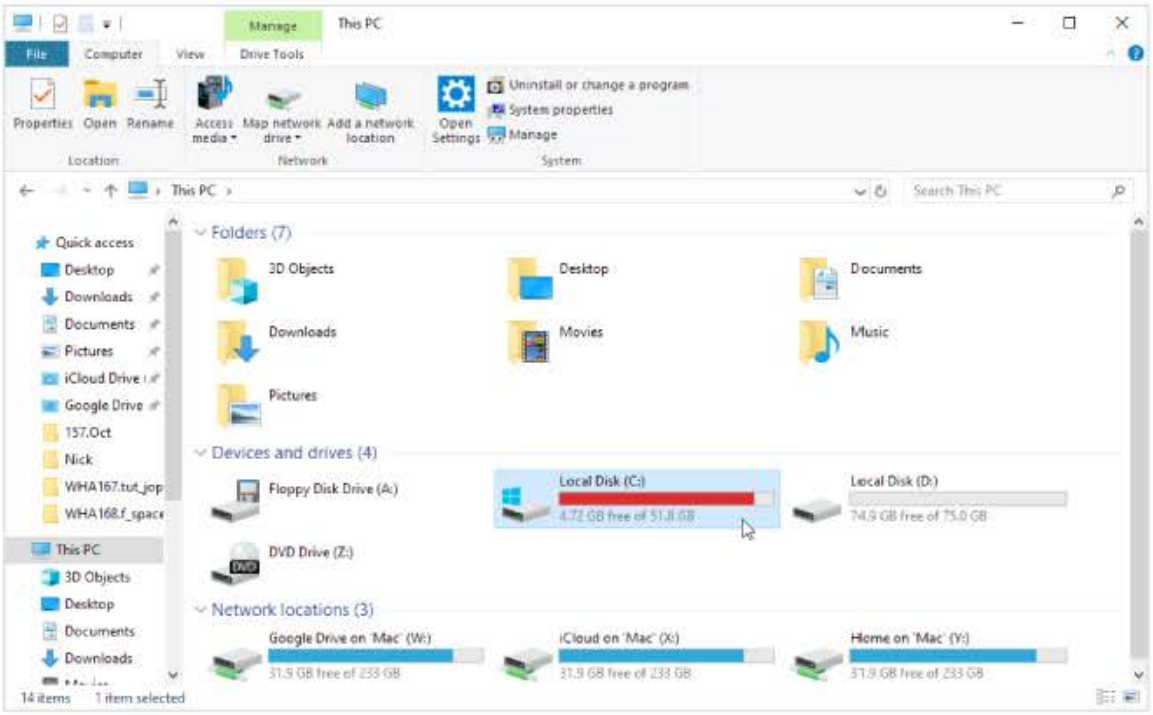


A red bar indicates that less than 10 percent of that drive's space remains free.

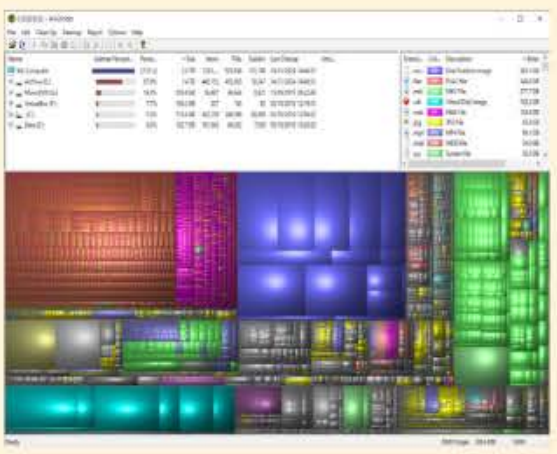
prevent your computer from running low on disk space.

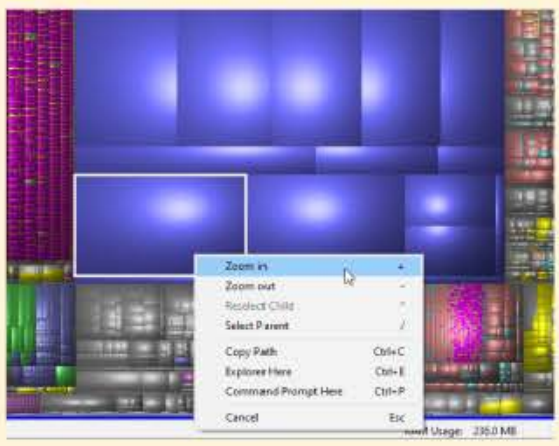
Although Windows has an "Other" view to cover large folders, it's not capable of easily highlighting the individual files and folders that are taking up the most space. To search for these requires a third-party tree-mapping app. Tree-mapping tools provide a visual representation of each file on your hard drive(s) in the form of blocks, with the size of each block corresponding to the size of the file in question.

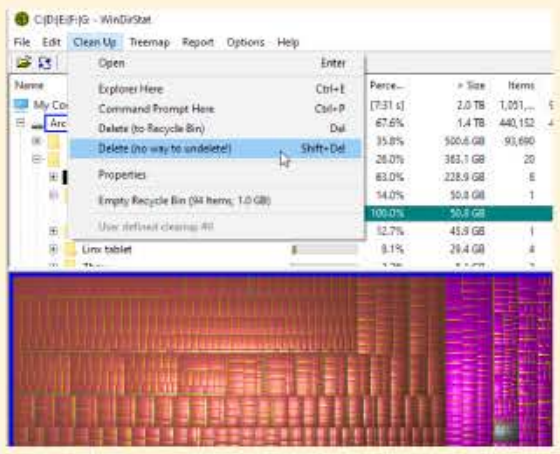
One such free tool is WinDirStat (https://windirstat.net), which you can download and install from its parent website or add to your PortableApps toolkit for running on demand. To add it to your toolkit, open the PortableApps platform and click "Apps → Get More Apps → By Category"—you'll find WinDirStat in the "Utilities" section. Once installed, right-click the program shortcut and choose "Run as administrator" to allow it to check your entire drive, then see the step-by-step guide below to find out how to use it to target and—if necessary—delete individual files. Check out the box below-left for an alternate tool should WinDirStat's garish interface put you off.

Once you've determined where all your drive space has gone, you can decide how to tackle the issue. So, turn the page....

MONITOR DISK SPACE WITH WinDirStat






File Edit Clean Up Treemap Report Options Help
Open Enter
Explorer Here Ctrl+E
Command Prompt Here Ctrl+P
Delete (to Recycle Bin) Del
Delete (no way to undelete) Shift+Del
Properties
Empty Recycle Bin (94 items, 1.0 GB)

1 VIEW A SUMMARY
You can choose to monitor all drives or focus on a specific drive. Make your choice and click "OK." Wait for WinDirStat to finish its analysis and you'll see a three-paned window. The bottom provides a color-coded "map" of your hard drive according to how it's being used.

2 INVESTIGATE IN DETAIL
Click an item on the map and its filename and path are revealed in the top-left pane, which shows a traditional folder view. Right-click and choose "Zoom in" to view a map of the next level down: either a specific drive or the folder containing your target file.

3 REMOVE LARGE FILES
When you've identified a file you think is safe to remove, select it and open the "Clean Up" menu. You can delete it directly from here or choose "Explorer Here" to open a File Explorer window pointing to the parent folder, enabling you to examine it more closely.

© WINDIRSTAT

CLEAN UP YOUR PC

Before buying more, ensure you're not wasting the storage you have

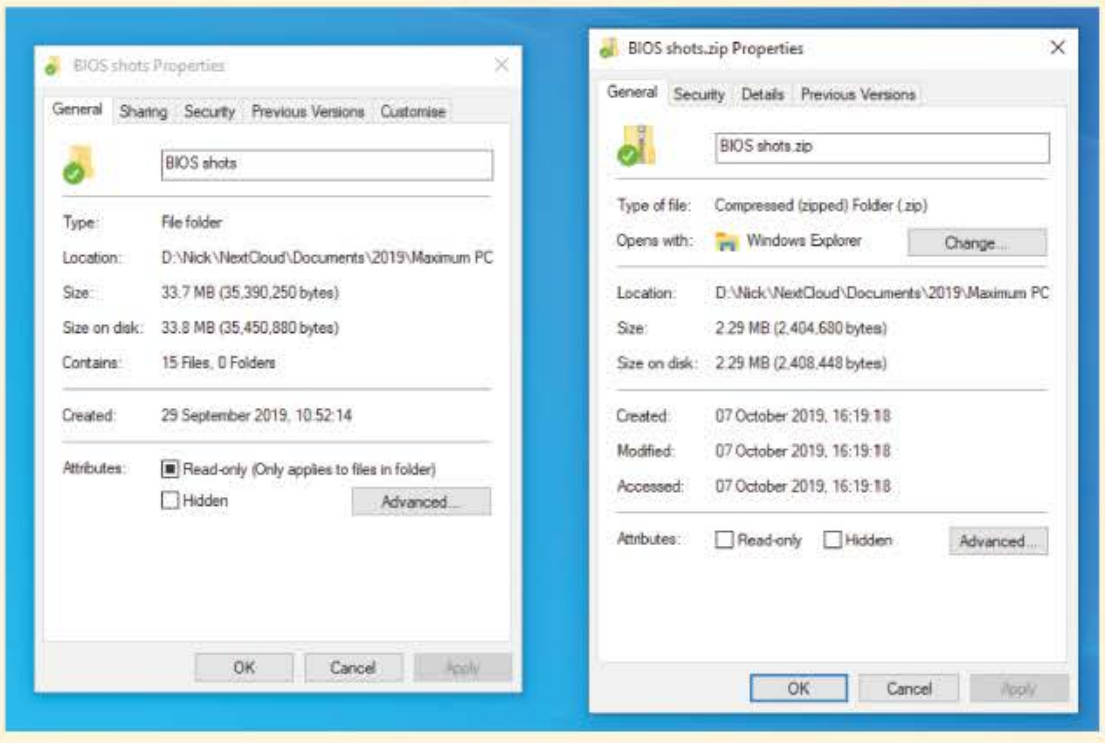
FREEING UP SPACE on your PC has never been easier, thanks to Windows 10's new Storage Sense feature, which is designed to render third-party apps such as CCleaner redundant. Your first job, therefore, is to employ its services to free up additional space on your drive. Navigate to "Settings → System → Storage," and click the "Configure Storage Sense or run it now" link. Flick the Storage Sense switch on and choose when to run the disk-cleaning tool—by default, it runs when you get low on disk space, but if you want to take a more pre-emptive approach, you can run it monthly, weekly, or even daily.

Scroll down, and you can configure more options—for example, removing temporary files, emptying files from the Recycle Bin after a set period, and periodically cleaning out the "Downloads" folder. You can also configure OneDrive's on-demand feature so that downloaded content reverts to online-only if unopened for 1, 14, 30, or 60 days. Desperate for more space? Click "Clean now" to perform a one-time clean-up.

FILES ON DEMAND

If you're a Microsoft OneDrive user, chances are you're already taking advantage of a relatively recent feature known as "on-demand." Instead of keeping everything physically stored on your computer, a series of shortcuts is created instead, pointing to the online files. These take up a fraction of the space, while ensuring your files are always accessible (so long as you're connected to the Internet). Simply open a file in the normal way, and it's downloaded to your computer, kept there indefinitely, or—if configured as outlined above—until the file hasn't been touched for a set period, at which point it reverts to being online-only to free up space on your PC until you next open it.

To verify the feature is on, right-click the OneDrive icon and choose "Settings → Settings tab," then check "Save space and download files as you use them."



ARCHIVE OLD FILES

Another way to save space is to move folders and files on to a secondary storage drive, such as a USB drive. If you don't have this luxury, you can save space by zipping up these rarely used files and folders instead. Right-click the item(s) in question, and choose "Send to → Compressed (zipped) folder," then wait for it to be combined into a single zip file. Right-click this and choose "Properties," then compare its size to the original file. If there's a significant saving, delete the original file or folder, then repeat to keep freeing up more space.

TRACK DOWN DUPLICATES

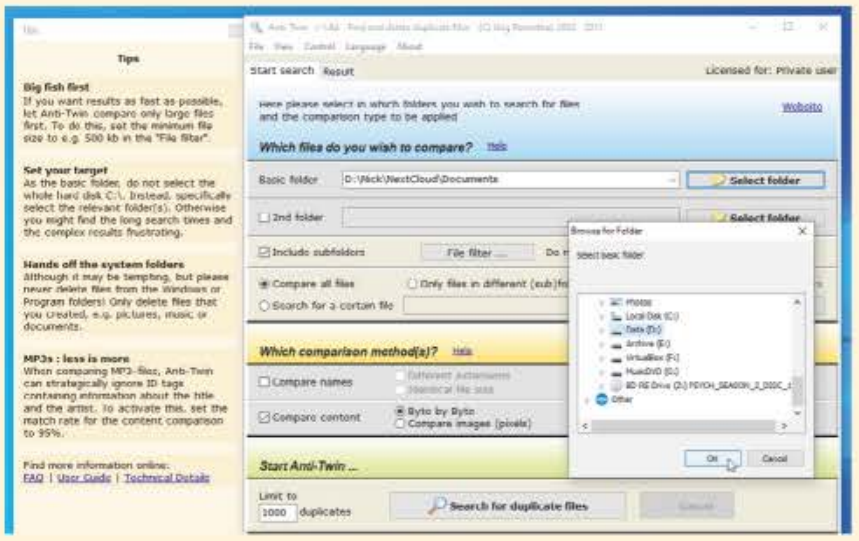
It's amazing how easily we generate copies of files—or near-duplicates, in the case of digital photos, with multiple attempts to get the perfect shot all somehow being left on your hard drive at the end of the process. In the past, we've looked to Duplicate Cleaner Free (www.digitalvolcano.co.uk/duplicatecleaner.html) and AntiDupl (https://ermig1979.github.io/AntiDupl/english) to cover these bases for free. The Pro version of Duplicate Cleaner—$29.95—can also hunt out similar files, but before investing, why not give AntiTwin (www.joerg-rosenthal.com/en/antitwin) a go?

Despite not having been updated since 2010, this no-frills tool works perfectly in Win 10 and can cover all your bases, as the step-by-step guide opposite reveals. Your selections are clearly marked before you commit to anything, and when you click to delete, you're given the option of moving files to a folder on the same drive for transferring elsewhere, sending them to the Recycle Bin, or deleting them directly.

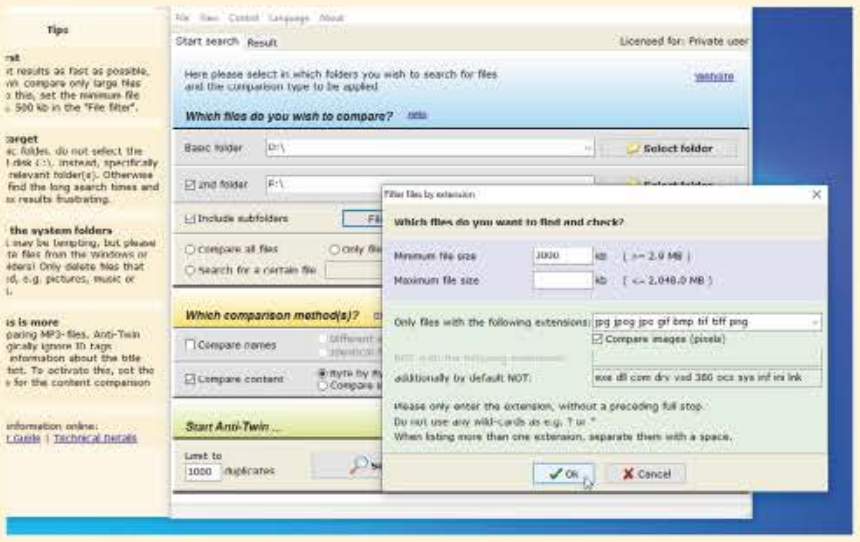
Look, too, for the option to replace the file with a symbolic link to the file you've kept—this means a program referencing the file you've deleted will be redirected to the remaining file instead, ensuring it continues to work correctly.

© MICROSOFT

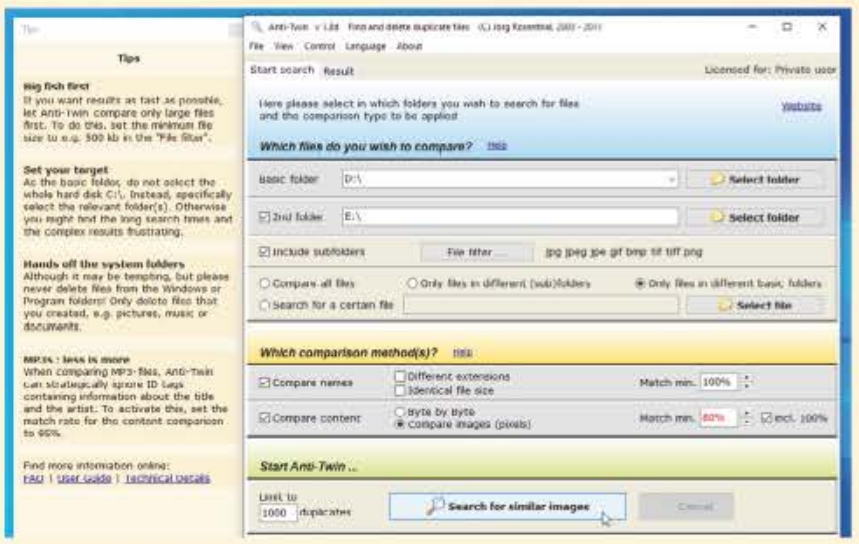
REMOVE DUPLICATES WITH AntiTwin



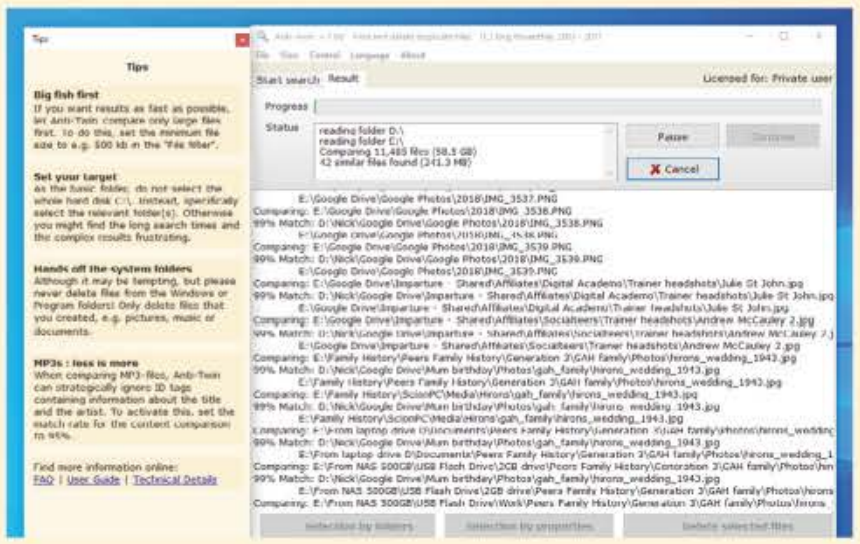
1 SELECT HARD DRIVE Open AntiTwin. Click “Select folder” next to “Basic folder” to select the root of your drive if you’re looking to clear up space on one drive only. Check “2nd folder” to select another folder path or drive if you’re looking to clear space across two hard drives by weeding out duplicates.



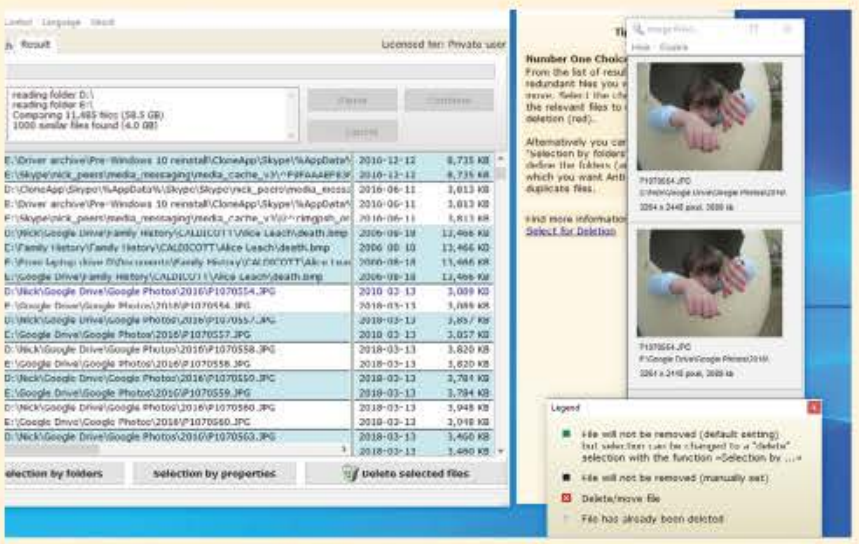
2 FOCUS SEARCH Leave “Include subfolders” checked and click “File filter.” You can exclude smaller files from the search (and speed it up) by setting a minimum file size. Click the drop-down as shown to focus on specific file types, and check “Compare images (pixels)” to look for visually similar images.



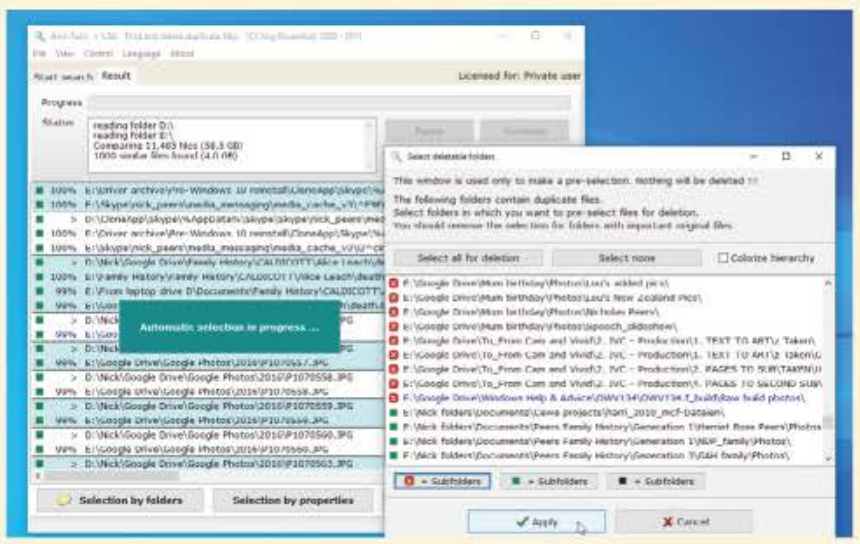
3 PICK YOUR COMPARISON METHOD By default, files are compared according to their content only, but you can also compare by name and file size if you wish. The “Match min” figure enables you to match similar, but not identical, files—this is best left for image searches only. Once done, click “Search.”



4 WAIT FOR SCAN A progress window appears—don’t be surprised to see it freeze occasionally as files are checked. You can pause or cancel the search at any time. After the folder contents have been read, files are compared to see which are duplicates and (if selected) close matches.



5 REVIEW RESULTS If you chose two paths, read the warning, but click “OK” as this would only be an issue if they were both pointing to the same folder. A list of all duplicates and similar files is shown, grouped together. Images can be compared by selecting one to reveal a pop-up window.



6 REMOVE DUPLICATES Right-click a file to decide whether to keep or remove it—you’ll also see options that enable you to mark specific folders as duplicates (see main text). After making your selections, use the legend to verify you’ve picked the right files to delete before clicking “Delete selected files.”

© JEORG ROSENTHAL

MOVE YOUR FILES

Transfer files elsewhere—on to another drive or into the cloud

THE MARCH OF TECHNOLOGY leads to increased demands on your system, particularly if you've discovered a space-hungry hobby such as gaming or 4K video editing. If you're simply looking to expand available storage for your files, you have two basic options. The first is to buy additional storage. Desktop users can check whether their PC case has room for a second internal hard drive—with 4TB drives at under $100, you can solve all but the most demanding needs with a single purchase.

Before splashing out, power down your PC, open the case, and verify there's a spare drive bay. Also, check your power supply has a spare SATA power socket (if not, Google "molex to sata power adapter" to find a cheap adapter) and a spare SATA slot on the motherboard. You also need a SATA data cable—these can be had for under $1, but ensure it's SATA III (6Gb/s), and consider a right-angled connector on one end for hard-to-reach sockets.

OTHER UPGRADES

An internal hard drive is better than an external model for reasons of speed, but this isn't always practical—for example, if you have a laptop. External drives may be more suited to long-term storage such as backups or archiving, but they can at a pinch be used for day-to-day use, although it's still a good idea to keep frequently accessed files on your internal drive.

If you want to go down the external drive route, you have two options: USB or NAS. USB prices are incredibly competitive—slightly cheaper, in fact, than internal models—so you can pay $90 for 4TB or push the boat out and get 6TB for $120. All models should now be USB 3.0, so for best performance, be sure to plug them into a USB 3.0 port (typically marked in blue) on your PC. Expect to pay a small premium for smaller, laptop-friendly 2.5-inch external drives, or consider network attached storage (NAS) instead. These solutions are slower, but use your network connection, so may be a more practical alternative should you not wish to have your laptop permanently connected to a USB drive.

Once your new drive is set up, you'll want to transfer your data across—the step-by-step guide below-right reveals how to do this for all your user folders, which are where the bulk of your data can be found.

MOVE SOME APPS

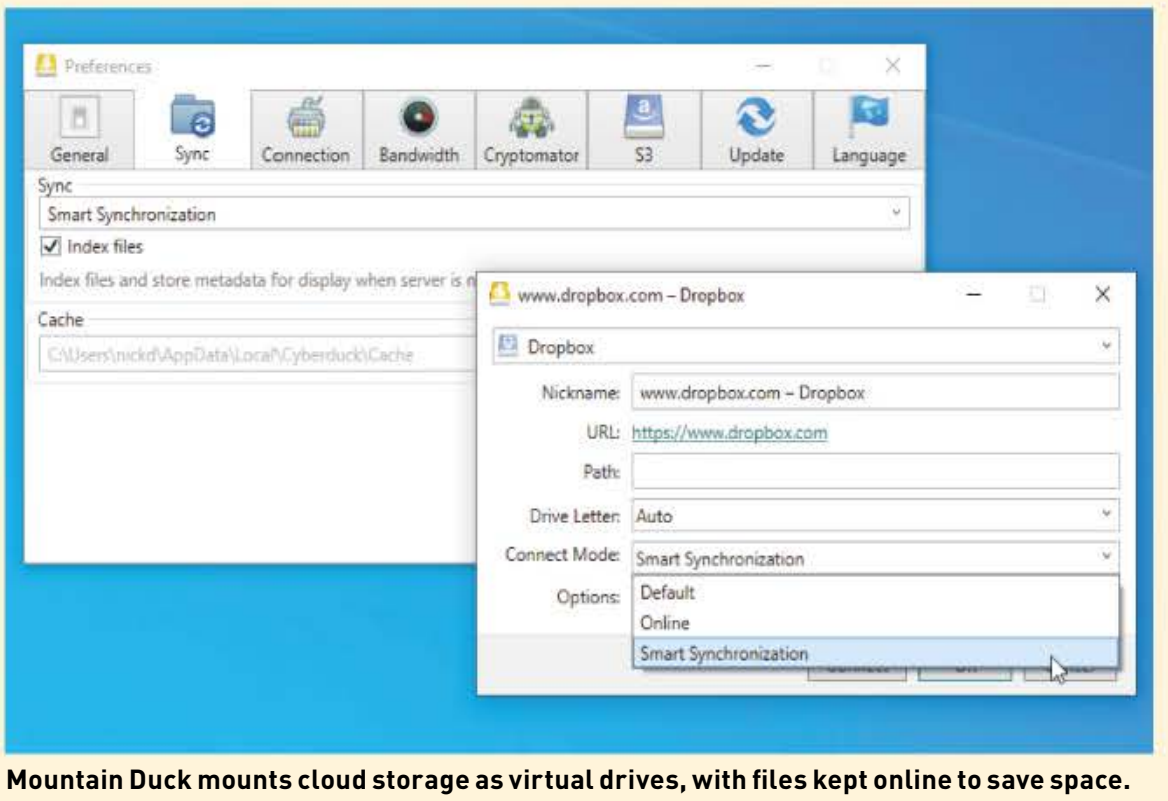
If you're running Windows on a very small boot drive—say 32GB—it's not enough to move data off your system drive, because you'll quickly run out of space for new apps, too. Where it's not possible to upgrade your system drive for a larger model (see over the page), you can also investigate ways of moving your programs from your system drive to your data one. One caveat: In most cases, your new data drive will be slower than your Windows drive, particularly if you boot from an SSD, so be prepared for a performance hit, and try to keep those apps you use most often on your boot drive.

There are two ways to move apps to a new drive: First, Windows Store apps (including those pre-installed with your PC, such as Photos) can sometimes be moved via "Settings → Apps → Apps & features." Click the app in question and

INTO THE CLOUD

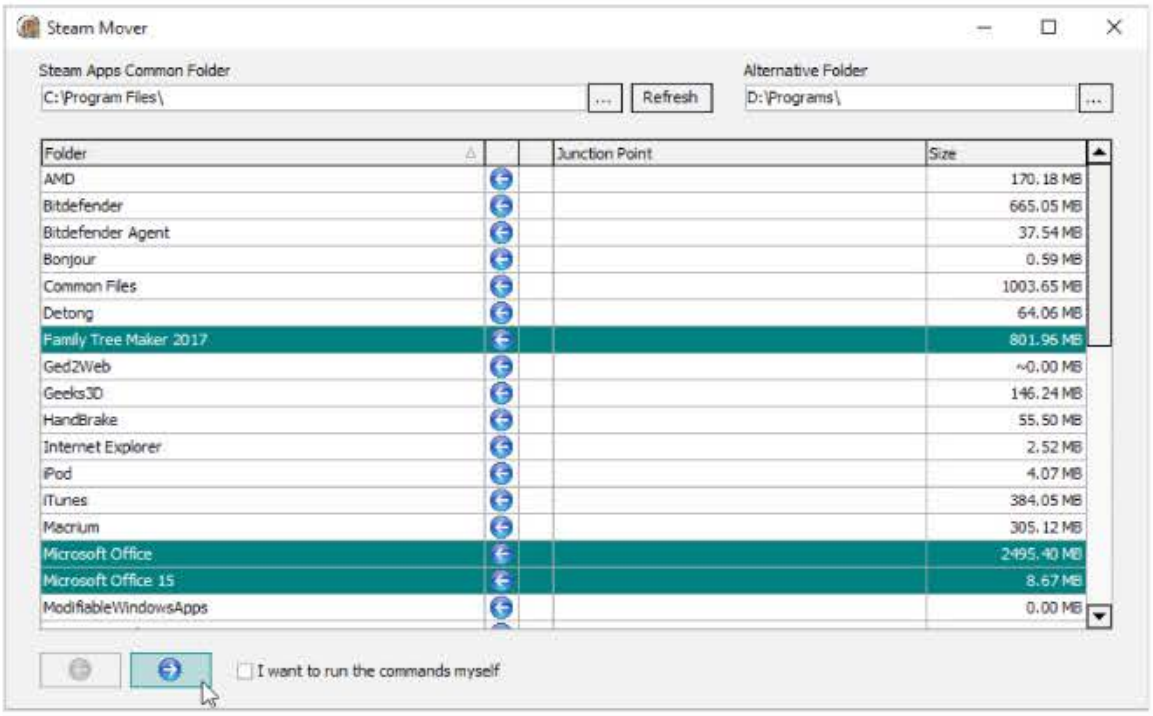
Another storage location you can use is your cloud provider. We've seen how you can use OneDrive to free up space on your PC, and other providers offer similar features in their paid-for plans—Dropbox (www.dropbox.com) calls its equivalent Smart Sync. You need to navigate to a folder inside your Dropbox folder, right-click it, and choose "Smart Sync → Online-only," or go to "Preferences → Sync," select your account, and choose "Online-only" to make it the universal default.

If you'd like to access Google Drive or Dropbox folders in this way without a paid account, for a one-off fee ($39) you can use a tool called Mountain Duck 3 (download a free trial from https://mountainduck.io). This can create a series of virtual drives connecting to a range of online storage services, and supports on-demand access like that found in OneDrive across all connected services. Set "Connect Mode" to "Smart Synchronization" the first time you add a new cloud account.



Mountain Duck mounts cloud storage as virtual drives, with files kept online to save space.

© ITERATE GMBH



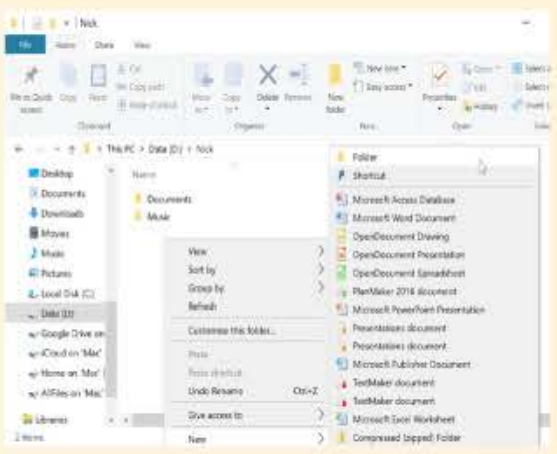
SteamMover enables you to move any program to another drive without reinstalling it.

look for a "Move" button—if it's not grayed out, click it, select which drive to move it to, and finally click "Move" again.

Regular programs are so well integrated into the operating system that you can't simply move their folder from the "Program Files" folder to your new drive. One option might be to uninstall and reinstall, but that comes at a cost of losing your preferences, and assumes the program in question allows you to choose where to reinstall the program.

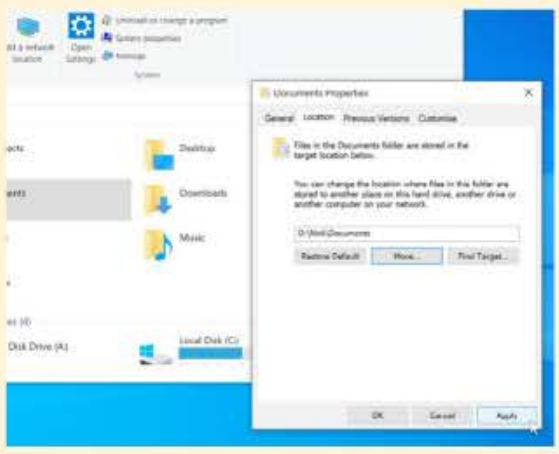
A simpler, foolproof option is to use SteamMover (www.traynier.com/software/steammover). This clever tool moves your program files to your data drive, but leaves a "symbolic link" in its place. This shortcut fools Windows into thinking the programs are still on your C drive, so they continue to work seamlessly. It's easy to use: Click "..." under "Steam Apps Common Folder," and select "C:\Program Files." Ctrl-click the programs you plan to move, based on their size and how frequently you use them, then click the right arrow button to move them all across. Changed your mind? Simply select your program and click the left arrow button to move it back, no questions asked. Windows 64-bit users should also check the "C:\Program Files(x86)" folder for 32-bit apps to move.

MOVE DATA TO A NEW DRIVE



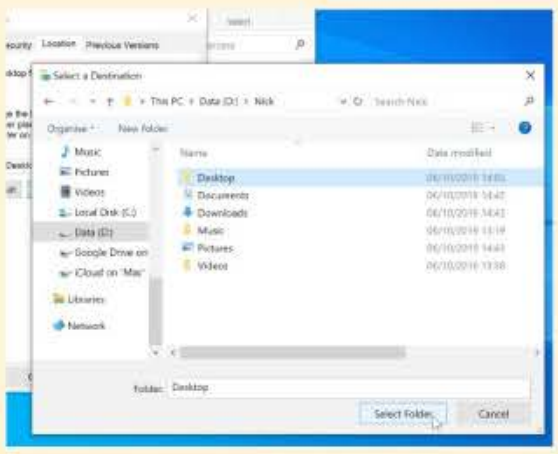
1 SET UP NEW FOLDERS

Open File Explorer and browse to your new drive. Create a new folder named after your username. Inside this, create more folders to match those shown under "Folders" in File Explorer's "This PC" view: "Documents," "Photos," "Downloads," and so on.



2 MOVE USER FOLDERS

Browse back to "This PC." Right-click "Documents" and choose "Properties → Location tab." Click "Move..." to browse to and select the "Documents" folder you just created. Click "Select Folder" followed by "Apply." When prompted, click "Yes" to move your files and folders to your new drive.



3 RINSE, REPEAT

Now repeat the process for all the other folders listed—be prepared for a long wait if you have large folders to move across to your new drive. The benefit of this approach is that once complete, you'll have freed up space on your system drive without having to delete anything.

© MICROSOFT

UPGRADE YOUR HARD DRIVE

Another way to increase storage is to migrate Windows to a separate, faster SSD drive

WHY NOT TURN your problem of storage space—or lack of it—into an opportunity? If you've not done so already, now is the perfect time to investigate one of the most effective upgrades money can buy: a fast solid-state hard drive to run Windows and your programs on. Switching from a clunky old hard drive to an SSD is like leaving the Stone Age. Windows loads in under a minute, apps open in a matter of seconds, and your computing life is no longer held up by clicking and waiting for files to load.

With SSD prices tumbling to put even relatively large amounts of storage space in your hands for a modest sum, there's never been a better time to make the move. The upside? Your old drive can stay in use as a dedicated drive for data, with tens—if not hundreds—of gigabytes of space freed up by moving Windows and your programs across to the new drive.

It's a three-step process: First, work out what your PC can accommodate, and pick the appropriate drive for the task. Once done, investigate the practicalities of fitting it to your PC, and then finally follow a method for migrating everything (or the key elements) off your old drive and on to the new one.

CHOOSE THE RIGHT DRIVE

If you're a laptop user, you're basically looking for a larger single drive to accommodate Windows, applications, and a decent amount of personal data.

This may involve moving from a relatively small SSD drive (say 128GB or less), or migrating from a large (say 1TB or bigger), but cumbersome drive. As always, while it's tempting to save money in the short term, try to stretch your budget to future-proof your purchase for as long as possible. With 500GB SSD drives weighing in at under $80, this should really be your minimum spec. Increase your budget to $120, and you'll find several 1TB SSD drives falling within your grasp, too. You'll then need to invest in a USB or NAS drive for those files you access less frequently.

If you're looking to upgrade a desktop PC, check to see whether your case can accommodate a second drive in addition to your current one. Chances are it can, giving you get the best of both worlds: a new SSD drive that can be smaller (say 256GB, or 500GB for those with a gaming habit or the need to run virtual machines), plus your old drive now exclusively used for data storage.

If you have a modern PC with support for the M2 NVMe interface (a small slot on the board into which SSD drives shaped like RAM sticks are plugged), pay the small premium for this type of SSD storage, because it's up to six times faster than SSD, never mind regular hard drives. Samsung's 970 EVO Plus is currently the best—250GB will set you back around $75, and 500GB around $110.

FIT THE DRIVE

The walkthrough opposite reveals how to clone a drive using Macrium Reflect Free. Note: Both old and new drives need to be connected to your PC at the same time. For desktop users, this means screwing in your new drive to an available 2.5-inch or 3.5-inch bay if connected via SATA, or slotting it into the NVMe slot, before pushing it down and holding it horizontally in place using the screw supplied.

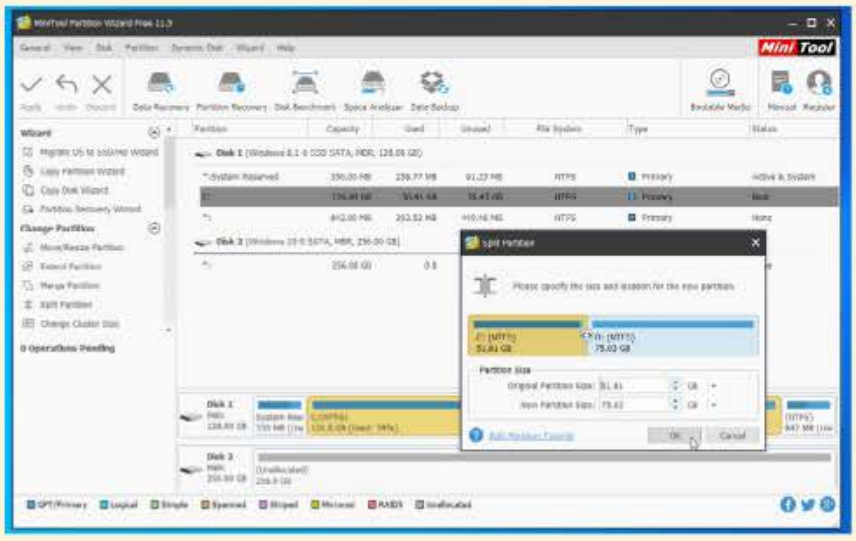
Laptop users have a choice: If you plan to keep the old drive as additional storage, invest $15–20 in a cheap USB 3.0 2.5-inch enclosure, and fit the new drive in there. If not, purchase a USB-to-SATA adapter from eBay for as little as $6, and use that to temporarily connect your new drive to a spare USB port. Once the old drive has been cloned to the new one, swap the two around, and your laptop should boot with all settings and data intact.

Watch Windows 10 (and startup apps) load in under 30 seconds with NVMe storage like this Samsung.

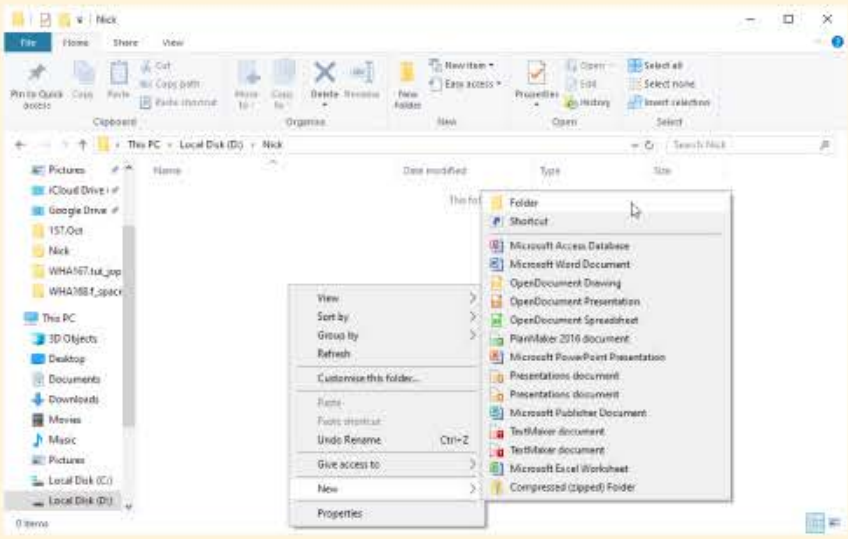
This $6 adapter makes it easy to attach any bare drive to your PC or laptop's USB port.

© iiTRUST, SAMSUNG

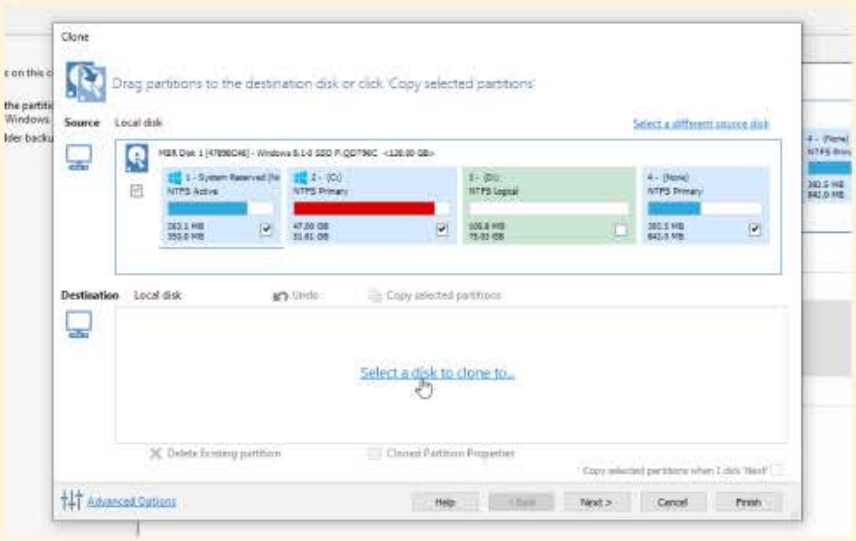
MIGRATE TO A NEW DRIVE



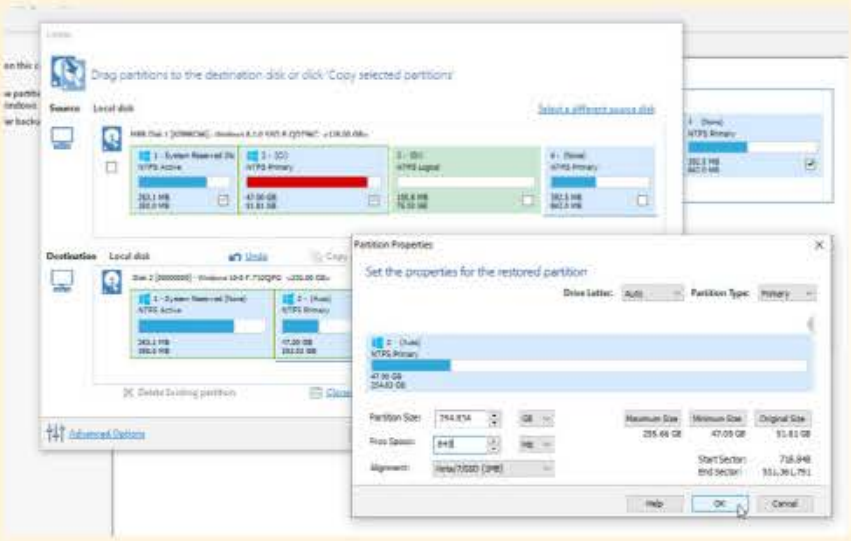
1 PARTITION OLD DRIVE Desktop users planning to migrate Windows and apps to an SSD while leaving data behind should first use MiniTool Partition Wizard Free (www.partitionwizard.com): Choose "Split Partition" and drag the slider as far left as it can go. Click "OK" followed by "Apply." Reboot when prompted.



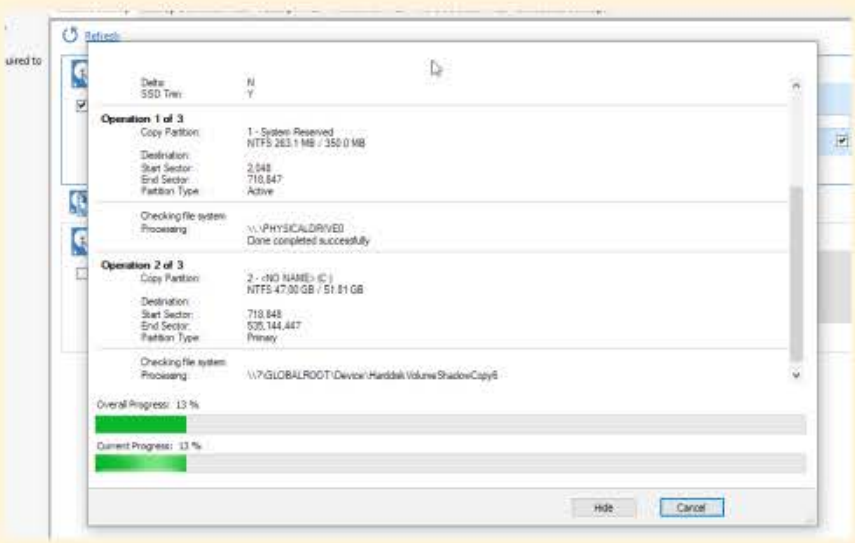
2 MOVE DATA TO NEW PARTITION Once complete, you should follow the three-step guide on page 39 on moving data to your new drive, using your newly created partition as the target. Next, download and install Macrium Reflect Free from www.macrium.com/reflectfree.aspx if you have not already done so.



3 SELECT PARTITIONS TO CLONE Launch Macrium. Select your Windows drive and click "Clone this disk." Make sure only the partitions you need will be copied across: System Reserved, the Windows partition, and any hidden partitions at the end of the drive. Uncheck any others, then click "Select a disk to clone to."



4 SET TARGET DISK Select your new SSD drive—the one with no partitions assigned. Drag each partition across—you need to click "Cloned Partition Properties" to resize your main partition after dragging it across. Set "Free Space" to match the last partition's size, click "OK," and drag the final partition over.



5 WAIT AS DRIVE IS CLONED Click "Finish." Uncheck "Save backup and schedules as an XML Backup Definition File" and click "OK" to perform the cloning operation. Each partition is copied in turn, a quick file check is done, then the actual cloning process takes place. Be patient—this may take some time.

6 FIT NEW SSD DRIVE Shut down your PC. Laptop users should swap out the current hard drive for their new SSD drive; desktop users need to reboot and make sure the new SSD drive is the primary boot device in the UEFI/BIOS settings. If all is well, Windows should boot—and much quicker than before.

© PARTITIONWIZARD

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THE GAMES OF 2020

What will be making your GPU groan in the next 12 months?

BY IAN EVENDEN

THE COMING YEAR will be interesting for gaming, due to the launch of the PlayStation 5 and Xbox Series X. The release of new consoles always shakes up the gaming landscape, as new capabilities are tested and developers take advantage of the increased processing power. But why should PC gamers care? Because the new consoles are based on AMD CPUs and GPUs, so it's less effort for developers to port console games to PC.

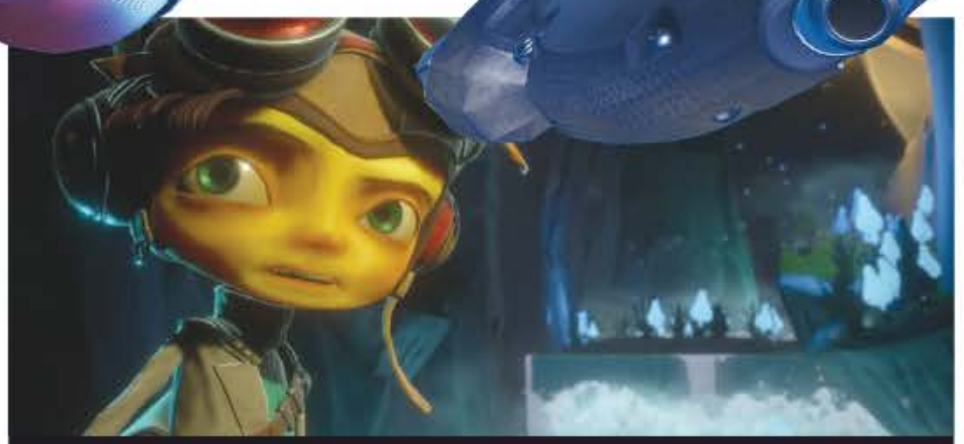
That doesn't mean they're going to, but with titles such as *Halo Infinite* and *Death Stranding* making their way to PC, along with every major multiplatform title, there's no reason to believe the PC will miss out on anything but the most tightly held platform-exclusive titles.

We've been in a golden age of PC gaming, with superior ports of titles such as *Red Dead Redemption 2*, and while the consoles may take a short-term lead, they're just an excuse to do what we love: upgrade.

Overwatch 2 TBA

Announced at BlizzCon in November, *Overwatch 2* is a sequel, but one that will stand side by side with the first game. New modes and heroes released with the follow-up will be made available for the original, and the two will co-exist in PvP. A new shared mode called Push sees teams tussle over a barrier-generating robot, pushing it into each other's territory, but other additions will be exclusive to the new game, with a focus on PvE and story missions.

• Publisher & Developer Blizzard Entertainment



Psychonauts 2 TBA

Tim Schafer's follow-up to the 2005 cult hit was meant to be here by now, but it's been delayed for additional polishing. We approve, because the *Psychonauts* universe is a rather wonderful thing, and deserves to be handled with care. The 3D platforming through the mental landscapes of various unfortunates seems to have survived the sequelization process unscathed, at least.

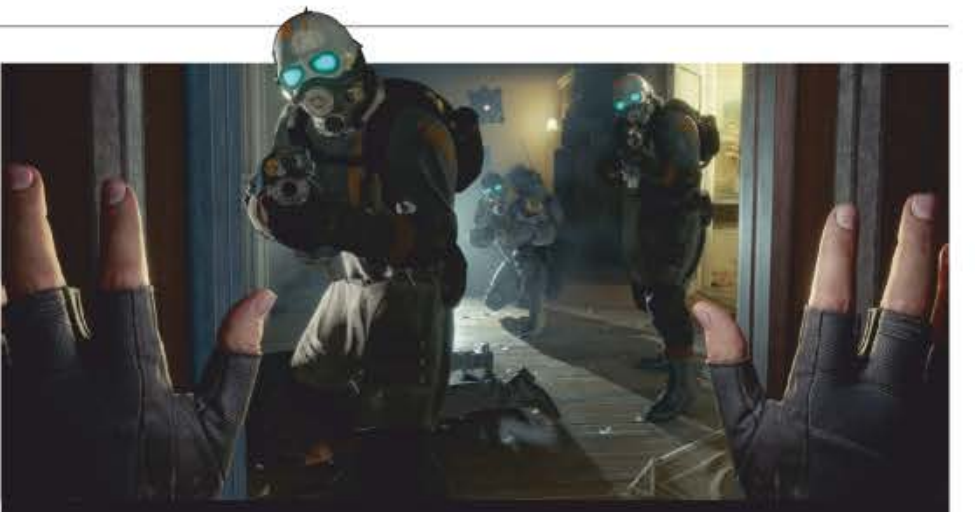
• Publisher Xbox Game Studios

• Developer Double Fine Productions

Watch Dogs: Legion TBA

It's worth seeking out the announcement trailer for this third game in the hack-'em up-series just for the heavily armed grandma character. Set in a near-future London, any NPC can be recruited to your cause, bringing their own stats and skills and tasers. You can hop from one to another, setting up a resistance movement against the tech-dystopia in which you live.

• Publisher Ubisoft • Developer Ubisoft Toronto



Half-Life: Alyx March

It's not *Half-Life 3*, but anything that gets us back to Combine-infested City 17 is a good thing, even if it does mean donning a ridiculous helmet. A VR-exclusive *Half-Life* game was the last thing we were expecting, but when it looks as polished as this, with Alyx's disembodied hands clearing shelves to create lines of sight in the trailer, we could be persuaded to step back into VR.

• Publisher & Developer Valve

Crusader Kings III TBA

How can you expand on *Crusader Kings II*, a dynasty simulator with more depth than the Atlantic? You can run it on a new engine, for one thing, and turn the character portraits 3D. Then you can take control with new resource Renown, legitimize your bastard offspring, and frighten your vassals into staying loyal. Deliciously, we're promised you can even invent new forms of heresy.

• Publisher Paradox Interactive

• Developer Paradox Development Studio

Kerbal Space Program 2 TBA

Plan a space program, build spacecraft, design colonies, and uncover the secrets of the galaxy. Sounds easy? The Kerbals' attempts to achieve orbit are beset by explosions. The sequel is designed to be easier to learn, but no easier to succeed.

• Publisher Private Division

• Developer Star Theory Games

Vampire: The Masquerade – Bloodlines 2 TBA

***Bloodlines 2* is set at Christmas, enabling you to bring a special kind of comfort and joy to those whose blood you drain. Inter-clan discord means it's the perfect time for a new vampire to rise to the top.**

• Publisher Paradox Interactive

• Developer Hardsuit Labs

Halo Infinite Q4 2020

Expect a flurry of ports at the end of the year as the new consoles launch. The sci-fi FPS *Halo* series, an obvious fit for the PC, has a turbulent relationship with the platform that will hopefully be soothed by the release of the *Master Chief Collection*.

• Publisher Xbox Game Studios

• Developer 343 Industries/SkyBox Labs

Tom Clancy's Rainbow Six Quarantine Q2 2020

A three-player co-op horror spin-off, *Quarantine* is set in the near future, and the trailer features enough aliens and weird black goo to make it look like the FPS *X-Files* game we always dreamed of.

- Publisher Ubisoft
- Developer Ubisoft Montreal

Doom Eternal March

Demons, grappling hooks, plasma guns, and some of the fastest ever multiplayer. New this time is Battlemode, in which two player-controlled demons stalk the Slayer, plus twice as many single-player enemies as in the 2016 game.

- Publisher Bethesda Softworks
- Developer id Software

Empire of Sin Spring

It's been a while since we've had a good gangster simulator. Starting in 1920, you have until 1933 to take control of Chicago by any means. Based loosely on real events, an element of random generation means no two maps play the same way.

- Publisher Paradox Interactive
- Developer Romero Games

A Total War Saga: Troy TBA

The Trojan war, so beloved of Homer, is the furthest back in time the *Total War* series has traveled. The *Sagas*, like 2018's *Thrones of Britannia*, are smaller games set around a particular historical flashpoint. In recreating the battles of Bronze Age Greece, the developers have added gods, heroes, and mythological creatures to the mix. Plus, we can only assume, a new wooden horse unit.

- Publisher Sega
- Developer Creative Assembly

Everspace 2 TBA

A space dogfighting, exploring, and trading game in which you're constantly on the lookout for better gear and hidden treasures. Set in a vivid open world, it sounds a lot like *Elite Dangerous*, but is strictly single-player. A virtually endless supply of ships and upgrades means you can take on anything from the smallest drone to massive capital vessels and huge alien beasts.

- Publisher & Developer Rockfish Games

World of Warcraft: Shadowlands TBA

Yes, it's still going. The eighth expansion pack for the all-consuming MMO shakes things up considerably, opening the world of the dead for exploration (so new hubs, dungeons, and raids), and reducing level 120 characters to level 50, with a hard cap at level 60. A "New Game +" experience will encourage veterans to start new characters, and dwarfs and trolls can now get tattoos.

- Publisher & Developer Blizzard Entertainment

Marvel's Avengers

May

Crystal Dynamics' first non-*Tomb Raider* game since 2006, this has no direct connection to the movies, but sees characters from across the Marvel universe team up against supervillains including The Abomination and Taskmaster, in both solo and co-op missions. The game marks the beginning of a "multi-game partnership" between Square Enix and Marvel, so we can expect a lot more where this came from.

- **Publisher** Square Enix
- **Developer** Crystal Dynamics/Eidos Montreal

Wasteland 3 May

To the frozen wastes of post-apocalyptic Colorado, where we find top-down turn-based combat, plus co-op for up to six players. Vehicles that can be driven and modified are new, as are team abilities that weaken all your opponents at once.

- **Publisher** Deep Silver
- **Developer** inXile Entertainment

Death Stranding Q2/Q3 2020

The game nobody could predict turned out to be different from all expectations on its console release—instead of a pure stealth shooter, it's about delivering cargo and reconnecting a network, with invisible enemies, and exploding corpses.

- **Publisher** 505 Games
- **Developer** Kojima Productions

Journey to the Savage Planet January

Join the fourth-best interstellar exploration company and drop on to a planet with little equipment or chance of success. Explore, catalog fauna, and determine if the planet is fit for habitation.

- **Publisher** 505 Games
- **Developer** Typhoon Studios

Humankind

TBA

Amplitude Studios comes in from the cold of *Endless Space* and turns its eye on human history. The game is still a 4X, but this time much more down to Earth. Randomly generated civilizations fight for control of a planet, starting in the verdant prehistoric era and hunting mammoth, before digging in for Bronze Age battles and five more ages of conquest.

- **Publisher** Sega
- **Developer** Amplitude Studios

Microsoft Flight Simulator TBA

The 11th *Flight Simulator* game goes all out. The entire Earth is simulated, using textures and topographical data from the always accurate Bing Maps. Microsoft's Azure cloud AI will do some heavy lifting, generating 3D assets from the map data and real-world weather reports. With the potential for two million cities and 40,000 airports, you might never fly the same route twice.

• Publisher Xbox Game Studios • Developer Asobo Studio

Gods and Monsters Fall 2020

Four years in development from the studio that brought us *Assassin's Creed Odyssey, Gods and Monsters* features a beautifully stylized fantasy (open) world in which you, a forgotten hero, roam until the Greek gods come to you for help. They're having trouble with Typhon, a monstrous winged serpent. The trailer shows Medusa, plus our hero hacking down a Harpy.

• Publisher Ubisoft • Developer Ubisoft Quebec

Minecraft Dungeons April

A new engine (Unreal 4), a new viewpoint (isometric), and a new genre for the building block series—this one's a dungeon crawler in the vein of *Diablo 3.* Expect a heavy emphasis on combat and loot as you explore procedurally generated branching levels in up to four-player co-op. Designed to be accessible, there's no mining or building, but enemies and enchantments from the original will return.

• Publisher Xbox Game Studios
• Developer Mojang

Werewolf: The Apocalypse – Earthblood Q2/Q3 2020

A transfer, like *Vampire: The Masquerade,* from a tabletop RPG, *Werewolf* is far more brutal. Your character is an eco-terrorist shapeshifter fighting a vampire-owned corporation that's polluting the forests. Keeping your rage in check is a struggle.

• Publisher Bigben Interactive
• Developer Cyanide

Destroy All Humans! Q1/Q2 2020

A remake of the 2005 game that first introduced the charming Cryptosporidium 137 and his anal probe. Crypto's mission to harvest human DNA is made more difficult by people running and screaming and shooting whenever they spot him.

• Publisher THQ Nordic
• Developer Black Forest Games

The Settlers TBA

Delayed from 2019, Blue Byte's remake/reinvention of the 1993 city-building/RTS game will use the Snowdrop engine previously seen in the *Tom Clancy's The Division* games. You can win a game through massed army combat, individual glory, or using "faith," taking over enemy territory by fomenting rebellion. The lighthearted medieval look is a great fit for your bustling villages.

• Publisher Ubisoft
• Developer Blue Byte

Grounded TBA

A survival game in which you play as a kid in the backyard. The twist here isn't that you're desperate for lemonade and cookies, though that may well be true, it's that you're tiny. It's certainly a cute premise, just as it was in *Honey, I Shrunk The Kids,* but Rick Moranis's offspring never had to deal with Unreal Engine 4-powered giant insects, towering blades of grass, nor baseballs the size of SUVs.

• Publisher & Developer Obsidian Entertainment

Dying Light 2 Q1/Q2 2020

A survival horror ARPG set 15 years after the first game in a world still full of undead. New protagonist Aiden Caldwell has parkour skills, a grappling hook, and a paraglider to help him get about, and the idea of using zombies as a cushion when you fall has a certain gruesome humor.

• Publisher & Developer Techland

Street Fighter V: Champion Edition February

It may be a series heavily associated with consoles, but there's no reason you can't get the arcade stick experience on your PC. Easy to start playing, but almost impossible to master, *Street Fighter V* is the most accessible the series has ever been, and this, the third edition to be released, contains every character and stage added to the game since its 2016 release.

• Publisher & Developer Capcom

Comanche Q1 2020

No mention of any voxel engines here, but we don't get enough helicopter games these days, so we're cautiously excited about this one, even if it isn't by Novalogic. It's a team-based multiplayer shooter, pitting highly maneuverable stealth helicopters armed with swarms of drones against one another, so hopefully we'll get the maximum overkill we've been looking for.

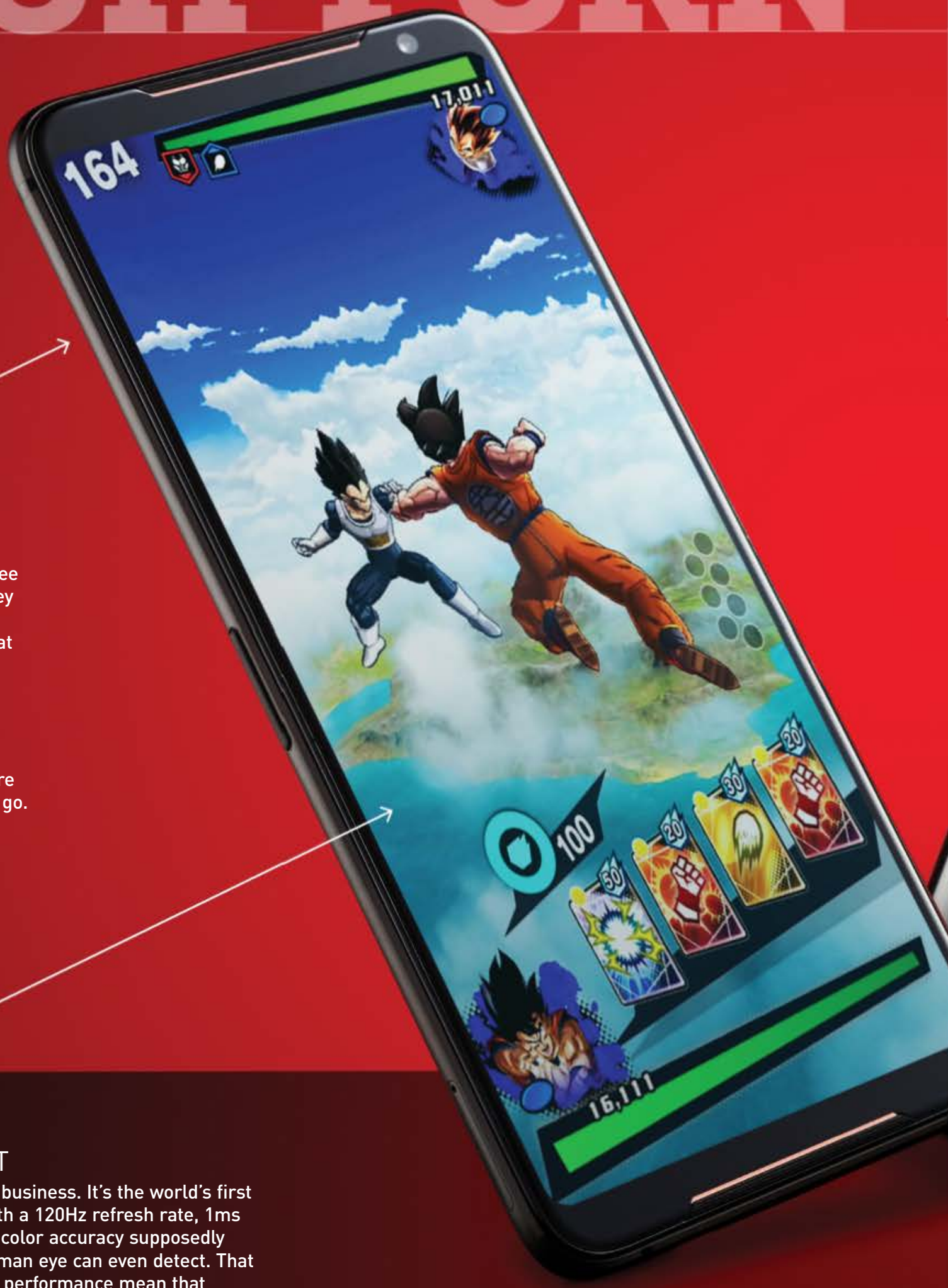
• Publisher THQ Nordic • Developer NUKKLEAR

Cyberpunk 2077 April

A sci-fi open-world RPG from the team behind *The Witcher 3,* and based on a long-running pen-and-paper game, *Cyberpunk* sounds rather like *Deus Ex* with the safety off. As brooding mercenary V, you explore the corporate-controlled Night City, buy apartments, get body modifications, and choose whether to go lethal or complete the game without taking a single life.

• Publisher CD Projekt • Developer CD Projekt Red

TECH PORN



1 BIG AIR

On the edge are three grooved "buttons," but they don't click. They're Asus's AirTriggers, touchpads that can act as triggers for gaming in landscape orientation. They also support gesture controls and have independent vibration features, for more immersive gaming on the go.

2 SHINE BRIGHT

This display means business. It's the world's first 10-bit AMOLED screen with a 120Hz refresh rate, 1ms touch response time, and color accuracy supposedly more defined than the human eye can even detect. That low latency and awesome performance mean that games on mobile have never looked better.

3 SAY CHEESE

A dual camera setup with a flagship Sony sensor makes for excellent photos. The main 48MP camera is supported by a 13MP secondary camera for ultrawide shots, able to capture up to 125 degrees of footage. The front 24MP camera is as ideal for livestreams as it is for selfies, too.

Asus ROG Phone II

MOBILE GAMING has hit a new high, with the release of the second model of Asus's smartphone, the ROG Phone II. With full games like *Fortnite* and *PlayerUnknown's Battlegrounds* migrating to mobile, phones need to be stronger, faster, and smarter than ever, which is what the ROG Phone II has been working toward.

Described by Asus as "the next step in the evolution of mobile gaming," the ROG Phone II was designed with gaming in mind: a massive 6,000mAh battery, up to 12GB of RAM, and a Qualcomm Snapdragon 855 Plus CPU. The Ultimate Edition even has a 1TB ROM for storage.

The Adreno 640 GPU puts this phone among the most powerful on the market, with numerous features to make it ideal for gaming. High-speed 4G LTE for minimum latency, fast-charging functionality, and serious cooling solutions. A redesigned 3D vapor chamber and a large copper heatsink work with internal and external vents to guarantee superior heat management.

Of course, no gaming device is complete without software, so the ROG Phone II uses an Android OS alongside two pieces of ROG-brand software: the Armory Crate and Game Genie. The former is a control center for mobile gaming, enabling you to tweak settings and fire up games from one integrated launcher. The Game Genie is a piece of optimization software that runs in the background while you play, with a toolbar that can be brought up to tweak settings on the fly. –**CHRISTIAN GUYTON**

4 SUPER COOL

Packaged in the phone's fuel-rod-esque box is an additional cooling unit, the AeroActive Cooler II, which extends over the back of the phone, and snaps into a custom connector to provide some extra cooling with a single fan.

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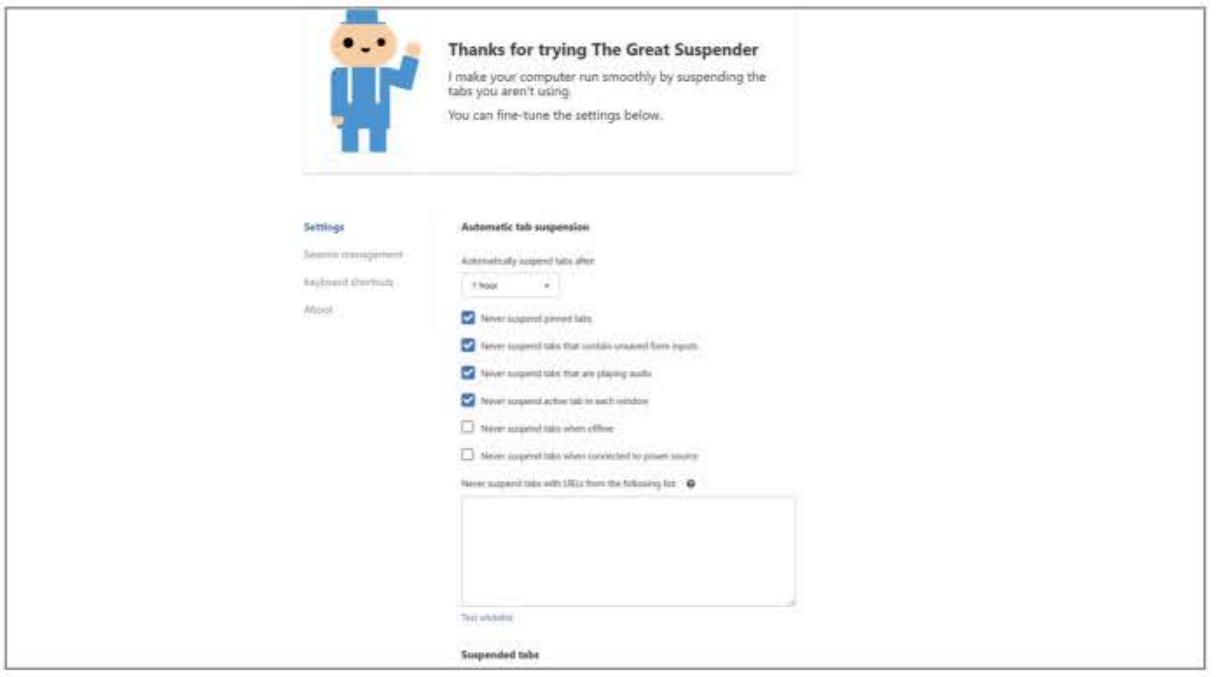
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

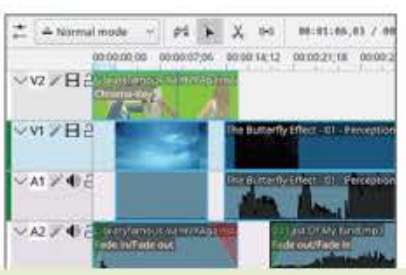
TIP OF THE MONTH


Thanks for trying The Great Suspender
I make your computer run smoothly by suspending the tabs you aren't using.
You can fine-tune the settings below.
Settings
Session management
Keyboard shortcuts
About
Automatic tab suspension
Never suspend pinned tabs
Never suspend tabs that are playing audio
Never suspend active tab in each window
Never suspend tabs when offline
Never suspend tabs when connected to power source
Suspended tabs

RECLAIM RAM WITH THE GREAT SUSPENDER

If you're the sort of Chrome user who keeps dozens of tabs open, you might want to check out The Great Suspender. An automated extension designed to keep Chrome's memory-guzzling ways in check, TGS suspends tabs you aren't currently using. You can tweak which tabs are suspended or not with a myriad of settings and a whitelist function, taking back control of your system's memory from Chrome.

MAKE – USE – CREATE



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Introduction to open-source video editor, Kdenlive

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Lay out your first pages with Serif's Affinity Publisher

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Step-by-step guide to putting together your first build

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CHRISTIAN GUYTON
STAFF WRITER

OOPS! ALL CORES

The third-gen Threadripper CPUs are out and about now, and boy, do they pack a punch. Unfortunately, that two-grand price tag means I won't be getting my hands on one for personal use anytime soon.

If I sound sad, let me assure you that I'm not. Looking at today's high-end desktop CPUs, all I feel is a faint sense of "why?" Nobody needs them. I could go online and empty my bank account for one. Or I could get a CPU for $250—one that comes with a cooler and doesn't force me to swap out my motherboard, too.

Why do these products even exist within the consumer space? Yes, there are people who have the cash to blow on absurdly expensive HEDT components, but it's easy to hit a point of diminishing returns. For me, who uses my own PC essentially just for gaming, streaming, and word processing, spending four figures on a processor is laughable.

Yes, these chips should be available to professionals and businesses for CPU-intensive work, but for the average joe? Surely, it's just to milk core-crazed individuals for their hard-earned cash with absurdly high prices? Call me a skeptic, but I don't think it's necessary for AMD and Intel to be pushing these CPUs out to the broader market.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

MacBook Pro 16-inch

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Apple has redesigned its notorious butterfly switches for this new laptop.

Under the knife this time is Apple's latest Pro-level laptop.

After taking apart the keyboard, it's time to de-lid the main unit.

BACKGROUND

A beloved old feature returns to the MacBook Pro: It starts with M-a-g. If you guessed MagSafe, we have disappointing news, but if you said "Magic Keyboard," we have the teardown for you. It's the all-new, butterfly-less, 16-inch MacBook Pro, and we're here to turn it inside-out.

MAJOR TECH SPECS

- 16-inch LED-backlit IPS Retina display with True Tone, 3072x1920 resolution (226 ppi)
- 2.6GHz six-core Intel Core i7 and AMD Radeon Pro 5300M
- 16GB of 2,666MHz DDR4 SDRAM, plus 512GB SSD
- 100Wh battery, six-speaker sound system, and high-performance microphone array

KEY FINDINGS

- Remember the iMac's Magic Keyboard? It's a well-liked, reliable design that Apple calls the "core technology" for the redesigned keyboard in this new machine; side by side, we're hard-pressed to spot any differences. Scissor switches, keycaps.... There's slightly less space around the keys, and pundits will celebrate those reconfigured arrow keys, but everything else looks nigh identical.
- Now let's look inside. Torx screws, schmorx screws—our Marlin driver set does it all. Apple touts major advances in this MacBook Pro's thermal design, and says this heatsink is 35 percent bigger. We also found upgraded hardware covering what we presume to be fast new GDDR6 chips—a copper shield and a couple of aluminum thermal pads.
- With the mobo out of the way, we can take a peek at the rest of the improved thermal design. The new MacBook Pro has noticeably larger exhaust holes than the 15-inch 2019 model. Combined with the new fans, which have bigger impeller blades, it all pushes 28 percent more air through the new Pro, allegedly allowing it to sustain up to 12W more during intensive workloads.
- The keyboard backlight assembly consists of a flexible diffuser, which carries light from LEDs along the edges. Beneath, we spot some Pentalobe P2 screws along the edges of the metal keyboard frame. Can we unscrew it to swap a busted key after a Dorito-fueled type-a-thon? No! Again, the keyboard assembly is riveted down. Although the switches are likely less vulnerable to crumbs, the keyboard isn't any more repairable than a Butterfly board.
- The new speakers have an extended enclosure, and opposed woofers top and bottom, which are supposed to cancel each other's vibration out. Kinda like the antinoise feature of the new AirPods Pro, but with bass. Antibass? We aren't as sure about the elongated enclosure, but we guess the new shape redirects sound to improve quality.
- Finally, the lithium powerhouse that's probably drawing a suspicious glare from the FAA: Apple's 99.8Wh battery (11.36V, 8,790mAh). That's the largest we've ever seen in a MacBook—a 4.8Wh increase over the 17-inch MacBook Pro, and a 16.2Wh increase over the latest 15-incher.
- Repairability Score: 1 out of 10 (10 is easiest to repair). The trackpad can still be replaced with very little drama. Minor components are modular, but the CPU, RAM, and flash memory are soldered to the logic board. Glue and/or rivets secure the keyboard, battery, speakers, and Touch Bar, so are a tricky fix. The Touch ID sensor is the power switch and is locked to the logic board, complicating repairs.

An Introduction to Kdenlive

YOU'LL NEED THIS

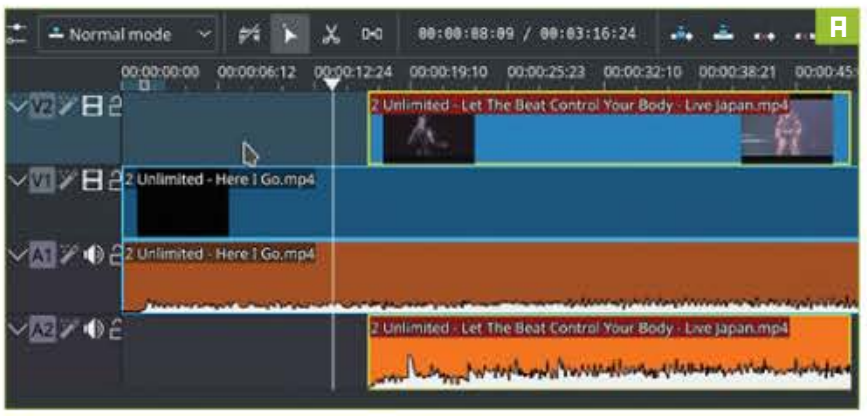
KDENLIVE
The open-source, multi-platform video editor is available for free from https://kdenlive.org.

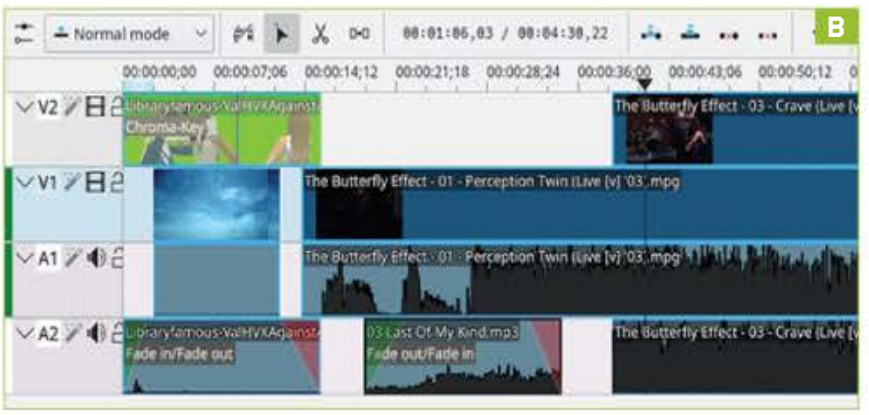
KDENLIVE HAS BEEN THE PRIMARY VIDEO EDITOR on Linux for several years now, but any videos on the topic consist either of torrents of loving adulation, or venom-infused rants about it being the worst thing since sliced Ebola. More recent versions have been ported to Windows, so it's time we let all PC users in on the fun.

Part of the reason some people may hate Kdenlive is that they can't figure out its workflow, so let's at least cover that, so you can hit the ground running. We can't show you all of Kdenlive, but we can show enough for you to get comfortable.

Along the way, we can show you what recent changes have taken place with the GUI, how to add some basic effects, where to find stock footage, and how to polish your audio. We'll even throw in a section on green screen effects and how to make them work properly.

Maybe after the journey, you'll even have become one of Kdenlive's loyal fans, but before we get too ahead of ourselves, let's start with the basics, and get it installed. –JOHN KNIGHT

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Normal mode
00:01:06,03 / 00:04:38,22
The Butterfly Effect - 03 - Crave (Live
The Butterfly Effect - 01 - Perception Twin (Live [v] '03 .mpg
Fade in/Fade out
03 Last Of My Kind.mp3
Fade out/Fade in

1 GETTING STARTED WITH KDENLIVE

From the Kdenlive download page (https://kdenlive.org), Windows users are given a choice of an installer version, or a self-extracting standalone version that doesn't need admin rights (but requires manually opening Kdenlive.exe in the "bin" folder). Both come in .exe format.

›› Linux users are spoiled for choice. Most distributions have a version in their repositories, but installation instructions are still provided for numerous systems. Repository or not, serious users should consider the third-party packages provided in AppImage, Snap, and Flatpak form. AppImages are particularly popular, with version archives going back to February 2017.

›› Kdenlive should be installed under your system menu, or can be started with the command:

```
$ kdenlive
```

2 INTERFACE BASICS

Your workflow centers around two fields: the Project Bin and the Timeline. The Project Bin is where all of your files sit, the Timeline is where all of your video editing takes place. First you import files into the Project Bin, then you drag files on to the Timeline to edit them.

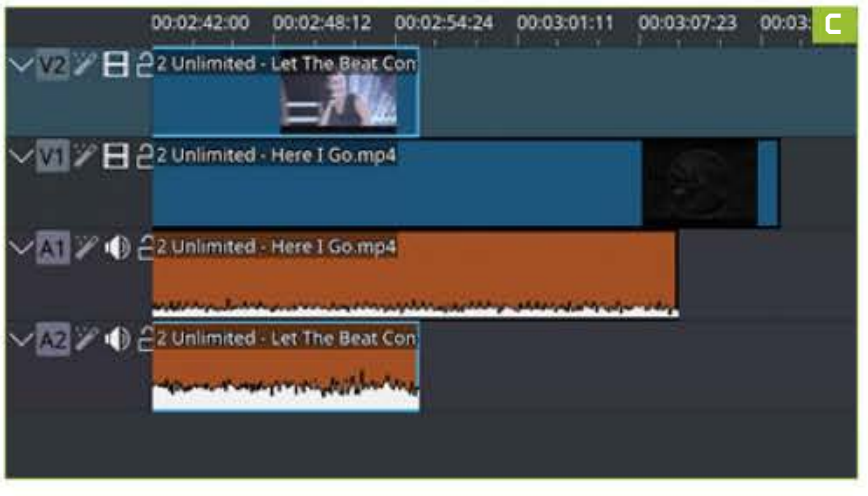
›› Files can be dragged and dropped from your file manager into the Project Bin, but nowhere else inside the Kdenlive window. Once you've placed a clip on the Timeline, you can move it forward and backward in time by holding down left-click and dragging the clip left and right.

›› At the top-right of the window is the Project Monitor, which is basically your preview window. Click the "Play" button and you'll see how your edited video will look at any point. You can fast-forward and rewind, or you can jump to any point in the video by clicking within the playhead below the video, or using the playhead above the Timeline.

›› New versions of Kdenlive have a different way of working with the Timeline, called Split Audio Tracks, that appears to be based around splicing together two audio/video (A/V) streams.

›› By default, a new project has the Timeline split into four tracks: two video (V1 and V2), and two audio (A1 and A2). The V1 and A1 tracks are in the middle of the timeline, whereas the V2 and A2 tracks are on the top and bottom [**Image A**].

›› As you drag a clip from the Project Bin on to the Timeline, Kdenlive automatically separates the audio and video streams into different tracks. Your main clip should go in the middle, where your audio and video



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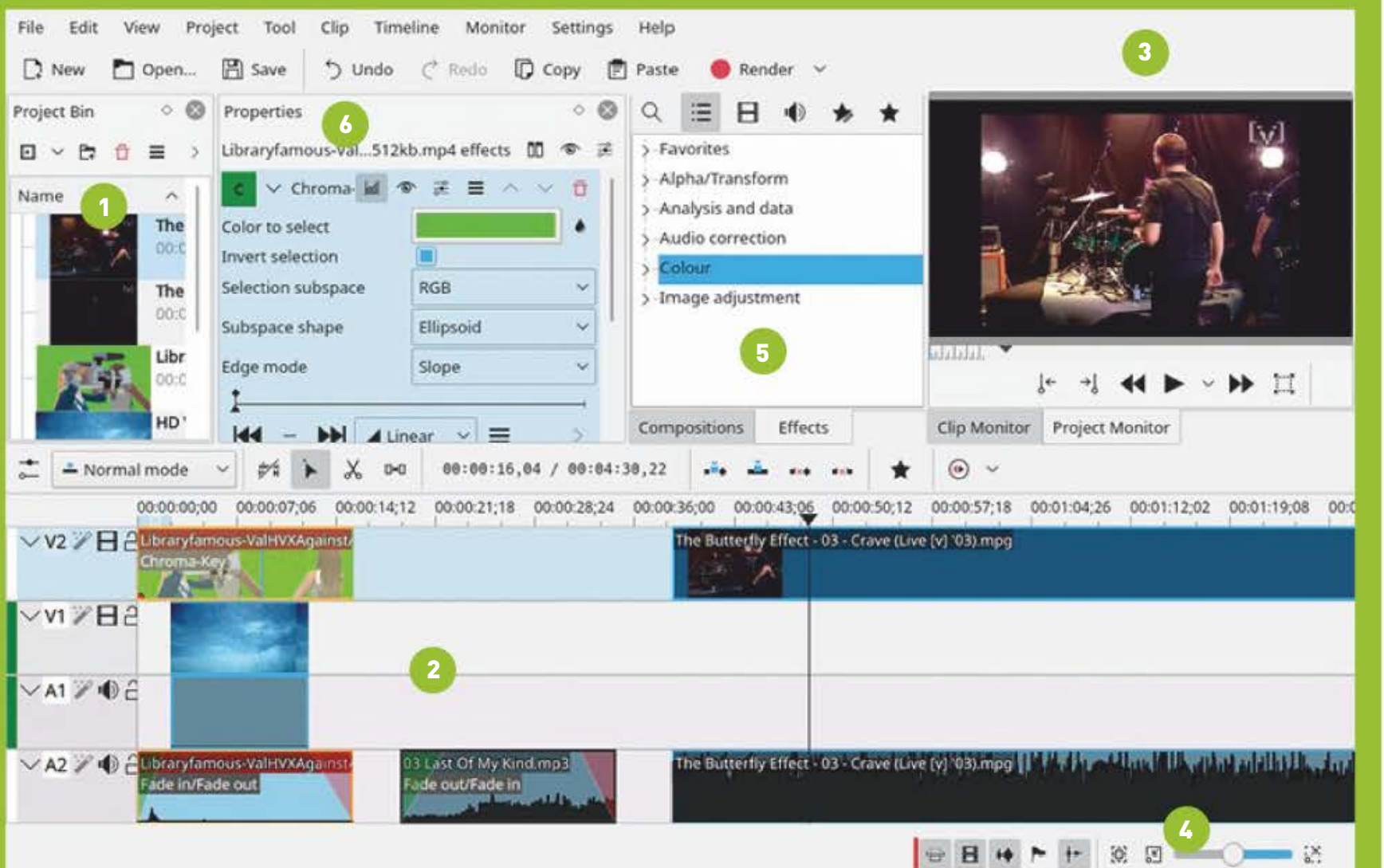
KDENLIVE GUI BASICS



1. PROJECT BIN
The placeholder for all files. Drag and drop files here first, not on the Timeline.

2. TIMELINE
The chief editing field, where all of your tracks and clips go, ready to be edited.

3. PROJECT MONITOR
Your preview window. Shows changes made to your video, such as splicing and effects, in real time.

4. ZOOM
Pulling left zooms out (all the way, and you will be viewing things in hour, instead of seconds), and pulling right zooms in, where you can see one second at a time. You can also hold Ctrl and use the mouse wheel.

5. EFFECTS
Choose from a list of effects, and drag and drop them on to clips in the Timeline. Note the separate tabs for "Effects" and "Compositions."

6. PROPERTIES
As you select clips, any applied effects can be browsed here, where you can also tweak their settings.

tracks are placed together. The clip you want to splice in should go on the outside of the main clip, which Kdenlive splits into the top and bottom of the Timeline.

›› That sounds confusing, but as you're dragging your clip around the Timeline, you'll see the clip split along the different V1-A1 and V2-A2 tracks, and it should make sense. If you don't want your tracks grouped this way, you can group each video track adjacent to its audio track by opening the track settings menu below the Project Bin, and choosing "Mixed Audio Tracks."

›› These combined audio and video tracks are referred to in Kdenlive as AV tracks, but you can add individual audio or video tracks if you desire. To add more tracks, from the main menu choose "Timeline → Tracks → Insert Track." Here you can choose "Video track," "Audio track," "AV track," or an "Audio record track" (perhaps you want to add some director's commentary).

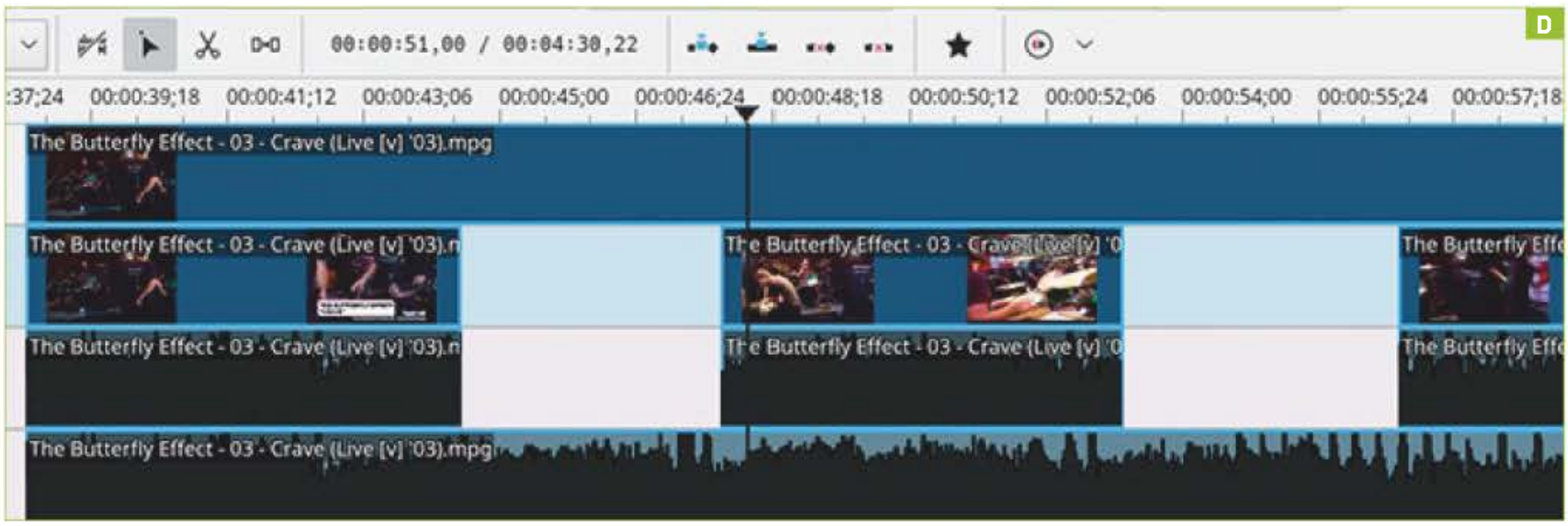
›› After choosing what kind of track you want, you can give it a name and choose where to place it in the Timeline. For instance, you could name a track "Background Music," then place it at the bottom of the Timeline by choosing "Insert track → Under → A2."

›› Note that you don't need new video or audio tracks for every clip. Multiple clips can be dropped on to the same track, which can simplify your workflow and lessen the resources needed to process multiple streams of video [**Image B**].

3 BASIC EDITING

Once placed, a clip is shortened by clicking its edge and dragging it inward, which can be undone by dragging it back again. Video tracks have an image at the beginning and end of each clip, previewing whatever frame of video is at that point. When you drag the edge of a clip, this preview frame updates, showing where you are in the video, and enabling you to correct your editing.

›› By default, AV tracks are locked or "grouped" together, and as you resize one, it resizes the other. To



work on tracks independently, right-click on a track and choose "Ungroup" [**Image C**].

›› To make a split in a clip, choose "Tool → Razor tool," or press X. Now, wherever you click in the Timeline, it marks a line in the clip under your cursor, and displays an image frame showing where the split was placed. When you re-engage the Selection tool ("Tool → Selection tool," or press S) you can drag in the edges where you made the split [**Image D**].

›› If all you want to do is move chunks of film around (and definitely not shorten a clip by accident), use the Spacer tool by choosing "Tool → Spacer tool," or pressing M.

›› Beyond different editing tools, Kdenlive also has different editing modes. On the left of the central toolbar, you can choose which kind of editing mode to be in. By default, Kdenlive is in Normal mode, which is what we have been using so far. But if you want to write pieces of footage over existing clips, choose Overwrite mode.

›› Now, if you drag and drop a clip over existing footage, the newest piece of footage overwrites whatever was underneath it. You can do this anywhere within an existing track. For instance, you could drop a corrected piece of audio or video over some corrupted footage without needing to complicate your project with added tracks.

›› If you want to place extra footage within existing tracks, choose Insert mode. Although you can drop footage anywhere you like in a track, we recommend finding the point of time you want to place more video by using the Project Monitor. Now place a visual reference by using the Razor tool, which places a line and shows whichever frames of video you're about splice between.

FREE RESOURCES

Kdenlive has a built-in function purely for grabbing free multimedia clips. Although free use is the idea, we can't guarantee everything is royalty-free—at the very least, you may need to attribute the author. Check the clip's license over thoroughly if you're unsure about your legal rights.

To give it a go, the utility is in the main menu under "Project → Online Resources." This opens a window with a search function for browsing pre-configured online libraries. If you open the "Service" drop-down menu, you can choose resources from the Freesound Audio, Archive.org Video, or Open Clip Art libraries.

The Freesound Audio library is great for things such as samples and background music. We found some excellent examples of gunshots, explosions, and ambient background noise—perfect for post-production audio. The Archive.org Video library has all kinds of material, and is a good place to start for green screen footage and video backgrounds.

We encountered an error with the Open Clip Art library, but that may have been the gods of good taste intervening. A better image source may be Creativecommons.org, which has licensing stipulations built into its search function.

4 ADDING EFFECTS

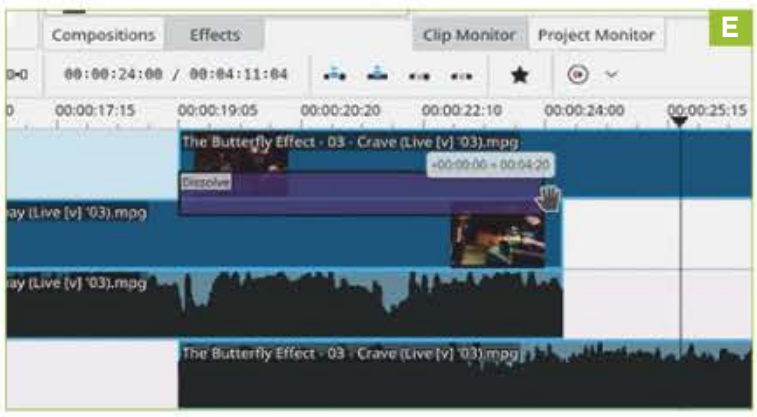
The most useful effect is a video transition, as it smooths over changes between scenes. We'll start with a Dissolve, then some green screen effects.

›› Before you attempt a video transition, you'll probably want to crossfade between any audio tracks, or the jump between scenes will be extremely noticeable—more so than with video—so see the boxout (right). Like an audio transition, a video transition also needs portions of overlapping footage, so leave some "tail" hanging off each video clip so the two tracks can be mixed together.

›› Open the "Compositions" tab and choose "Dissolve." Click and drag "Dissolve" on to the border of the adjacent video tracks between the overlapping section of video [**Image E**]. If placed correctly, the Dissolve should be sitting partly on top of the inner track and the outer track.

›› Like clips on the Timeline, a Dissolve has a draggable edge that can be shortened or lengthened, making the transition more or less abrupt. When you play the results in the Project Monitor, the two streams should dissolve into each other, instead of changing with a jump.

›› If you select the Dissolve itself, some options display in the Properties panel above. It's worth trying the "Reverse" option, which flips the way the Dissolve works, giving an interesting way of transitioning between scenes that could give your editing an extra something.



5 GREEN SCREEN EFFECTS

Green screen effects are surprisingly easy to create, although there are some quirks to the interface. Of course, not everyone just has a green screen lying around, so if you want to follow along without needing to drape your den in green bed sheets, see the "Resources" box on the opposite page for information on finding experimental footage.

›› What confused us at first was the order in which you place tracks. The newest video track is the one that displays in the Project Monitor. Therefore, put the background track in first (V1), then put the thing you are going to overlay (the clip with the green background) in V2 or a later track.

›› With both clips in place, select the green screen track by clicking within the actual clip itself, not the "Track Name" sidebar. Now go to the "Effects" menu, open "Alpha/Transform," choose "Chroma-Key," then click and drag it on to the green screen overlay track [**Image F**].

›› If you click the "Play" button in the Project Monitor, chances are that it won't work immediately—first you have to tell Kdenlive what specific color and shade to look for. If you look to the panel on the immediate left, you'll see "Color to select" and the color selector droplet icon. Click the color selector, then click the green background from your video in the Project Monitor.

›› Now when you click "Play" in the Project Monitor, you should see your green screen layer play over the background video.

›› If your overlay video is suffering from green borders, or parts of your video overlay are missing, you can fine-tune settings such as hue and chroma (drag down the edges of the panel if you can't see these settings). Try turning up the chroma settings until parts of your on-screen characters start to disappear, then turn it back a little.

6 EXPORTING YOUR WORK

Once you've finished your masterpiece, you'll want to show the world, but there's one more step. Simply saving a project doesn't result in a finished video; you need to export it into a regular video file. For this, you need to perform a "render."

›› From the main menu, choose "Project → Render." The Rendering window now opens, giving you a choice of formats for encoding your video. Choose your filename, and if you're ready to commit, click "Render to File."

›› With the standard settings, this could take a long time. By default, Kdenlive only uses one CPU thread. If you click "More options," you can select how many threads to assign the encoding job. Using more threads dramatically decreases rendering times, but you need to know how many threads your CPU can use—this should be at least as many cores as your CPU, twice if your CPU supports Hyper-Threading (or SMT for AMD's chips). We'll leave you to find out your CPU's tech specs....

7 WHAT DO YOU THINK?

As we said in the intro, Kdenlive seems to be a love it or hate it kind of program, and some criticisms are quite valid. Yes, it is free, in both the open-source sense and the gratis sense. Yes, it is genuinely powerful in its abilities, and for certain people, the workflow really seems to flick their switch. File format support is good, working with even relatively obscure formats, and it has lower hardware requirements than the competition, which is no small feat.

›› Nevertheless, the interface can be counter-intuitive, there are quite a lot of changes between releases, and documentation is often lagging behind GUI redesigns. Kdenlive is also notorious for crashing—at least, with certain versions.

›› Our advice is to save your work frequently, and if you have a stable release that works nicely, keep that version and be cautious about upgrading. If things aren't working out, try another version. Linux users may want to try specific AppImage releases, rather than rely on packages supplied by their distribution.

›› Still, you can't please everybody. Hopefully Kdenlive will fit your style, falling more into the "love it" than the "hate it" category.

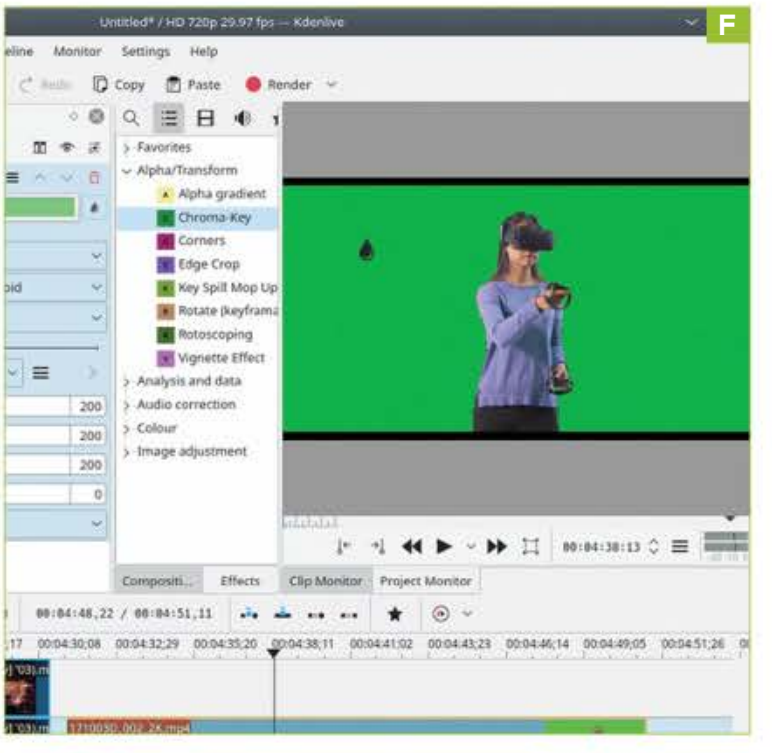
FADES

For fading audio tracks in or out, Kdenlive has a fade function similar to big audio editing suites. Obviously, a fade in is for the start of a track, and a fade out for the end. We'll use a fade out for this explanation.

This is slightly awkward to explain, but to fade out, you grab the top-right corner of a track, then drag it inward. However, in Kdenlive, the controls are already complicated by the edge controls moving the track around. Therefore, rather than the top corner, the fade control is in the top corner and slightly back along the top of the track.

You'll know it when you see it, because a red ball starts pulsating under your mouse cursor, or a green ball if you're fading in. Click the ball and pull it in toward the inside of the track. You'll now see a diagonal line drawn across the audio track, and a numerical read-out in seconds.

The fade can be as long or as short as you like: The longer the fade, the more drawn-out and gradual the effect; the shorter, the more abrupt.



Build a Better nginx Reverse Proxy

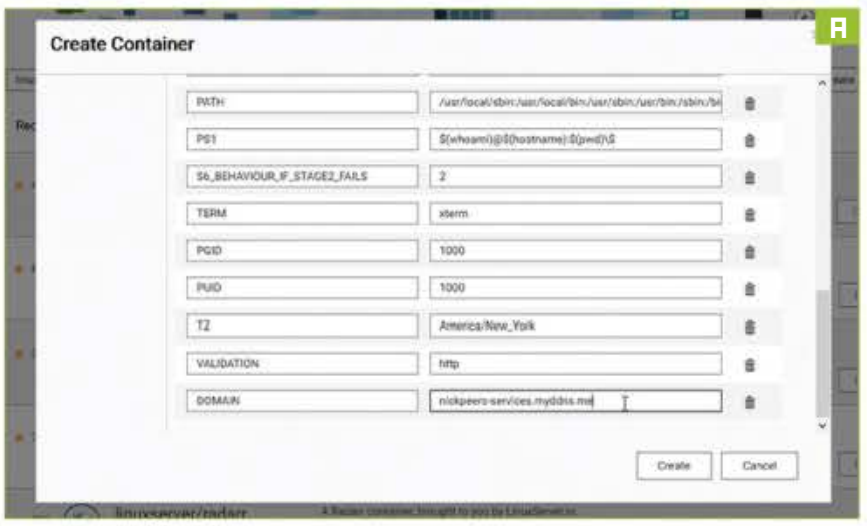
YOU'LL NEED THIS

MACHINE CAPABLE OF RUNNING DOCKER CONTAINERS
Plus last month's tutorial for domain configuration.

LAST ISSUE, WE SHOWED YOU HOW TO SET UP a secure reverse proxy with a combination of nginx and Lets Encrypt, using a standard Linux or Windows PC. This time around, we're going to deliver the same combination through a single Docker container from LinuxServer, which enables you to set up the reverse proxy without having to dedicate an entire physical or virtual machine to it.

Because the most logical place for this container will be on a low-powered machine running 24-7, we've focused on the powerful QNAP range of NAS drives, using the company's Container Station app to set things up—visit https://blog.linuxserver.io/2019/04/25/letsencrypt-nginx-starter-guide/ for a step-by-step guide to getting this running in Windows or Linux.

Once done, we'll reveal how you can take full advantage of the container, which is designed to make it easy to use a combination of subdomains or subfolders to simplify the process of directing traffic to the correct server, complete with a host of pre-built configuration files to help you quickly make your favorite servers remotely accessible in a secure way. **–NICK PEERS**



A

1 INSTALL ON QNAP

If you're a QNAP user, open Container Station, select "Create," and type "linuxserver letsencrypt" in the Search box. Select the first result ("linuxserver/letsencrypt"), click "Create," leave "Latest" selected, and click "Next." In the "Create Container" box, we recommend limiting CPU to 20 percent and memory to 1024MB. Now click "Advanced Settings." Add these environment settings [**Image A**]: PUID = 1000, PGID = 1000, TZ = America/New_York, VALIDATION = http. Change the TZ field to match your timezone (https://en.wikipedia.org/wiki/Tz_database).

›› Next, add URL = domain.com, replacing "domain.com" with your own domain or dynamic hostname. If you're using your own domain and plan to use one or more subdomains for the servers, create a SUBDOMAIN value listing each subdomain, separated by a comma (for example: SUBDOMAINS = bw,nc), plus change the existing ONLY_SUBDOMAINS value to "true."

2 COMPLETE CONFIGURATION

Select "Network" and change "Network Mode" to "Bridged." Select "Use static IP" to assign a unique IP address to your container, through which all subsequent traffic will be forwarded. Finally, select "Shared Folders" and click "Add" under "Volume from host" to map /config (mount point) to a suitable folder on your NAS drive (say /Containers/letsencrypt, which you need to create in File Station). Now click "Create." Switch to "Containers," and after your LetsEncrypt container appears and starts running, click to monitor progress through the console. When complete, click the link that appears in the URL field to confirm your reverse proxy is up and running.

3 VIEW AND EDIT CONFIG FILES

All configuration files are stored outside the container, so you can destroy and recreate the container without losing your settings. Docker users should navigate to the folder they mapped with -v flag when setting up the container; you can then edit the files using your text editor before using "docker restart" to restart the docker to apply your changes.

›› QNAP users must open File Station and browse to the "/Containers/letsencrypt" folder. You'll then manually download any files you need to configure (select the file, click the spanner icon, and choose "Download"), open them in your text editor to make changes, then save and upload the changed file through File Station (overwrite the original when prompted). Switch back to Container Station, select your LetsEncrypt container, and click "Stop" followed by "Start" to restart it. Keep an eye on the console—if there's a problem with your configuration file, it should list it here. Click "Stop," check the file, then reupload before trying again. If you see "Server read," things should be working.

default | nextcloud.subdomain.conf | nextcloud.subdomain.conf.sample

B

```
13 #  ),
14
15 server {
16     listen 443 ssl;
17     listen 32770 ssl;
18
19     server_name nc.*;
20
21     include /config/nginx/ssl.conf;
22
23     client_max_body_size 0;
24
25     location / {
26         include /config/nginx/proxy.conf;
27         resolver 127.0.0.11 valid=30s;
28         set $upstream_nextcloud 192.168.35.2;
29         proxy_max_temp_file_size 2048m;
30         proxy_pass https://$upstream_nextcloud:32770;
31     }
32 }
33
```

4 VIEW DEFAULT CONFIG FILE

Browse to "nginx/site-confs," where you'll find one file: default. Save a backup copy before opening it in your text editor. You'll see there are subtle differences from the default file we introduced in last month's tutorial, most notably this line:

```
include /config/nginx/ssl.conf;
```

›› This basically points to a file where all that SSL configuration we applied last month for hardening your security is stored. It keeps things simple—everything is one place, and has already been pre-configured for you. Before moving on, however, insert the following line directly above it:

```
add_header X-Robots-Tag "noindex, nofollow, nosnippet, noarchive";
```

›› This line helps keep your domain hidden from search engines, ensuring it's not widely advertised on the Internet.

5 ADD REVERSE PROXIES

Navigate to "nginx/proxy-confs." In here you'll find a wide array of sample files with the name "server.subdomain.conf.sample" or "server.subfolder.conf.sample." See if your server is listed. Let's take Bitwarden as an example, based on our feature on password managers in the December 2019 issue.

›› Open "bitwarden.subdomain.conf.sample" in your text editor. Now edit the file by altering the following lines: server_name should point to your subdomain (such as bw.*; for Bitwarden), while $upstream_bitwarden should point to your Bitwarden server's IP address. Finally, alter the proxy_pass port number so it points to the port you allocated for 80 (this was 4000 if you followed our tutorial in the December issue, or just 80 if you set up Bitwarden_rs with a bridged network, so it has its own unique IP address.

›› Once done, save the file as "bitwarden.subdomain.conf" and place it back in the "nginx/proxy-confs" folder if necessary. Restart your LetsEncrypt container, then open your browser and go to https://bw.domain.com—there it is, ready for secure remote access through web browser and mobile app alike.

6 EXTRA PI

Repeat for other proxies—when it comes to configuring NextcloudPi, you need to perform some additional tweaks: Basically, be sure to listen out for the https port you configured under "Networking → NC forward ports" in your server block, then redirect traffic to that port within the location block [**Image B**].

```
GNU nano 3.2                                    default

        #auth_request /auth;
        #error_page 401 =200 /login;

#        include /etc/nginx/proxy.conf;
        resolver 127.0.0.11 valid=30s;
        set $upstream_bitwarden 192.168.35.5;
        proxy_pass http://$upstream_bitwarden:80;
    }

    location /notifications/hub {
#        include /etc/nginx/proxy.conf;
        resolver 127.0.0.11 valid=30s;
        set $upstream_bitwarden 192.168.35.5;
        proxy_pass http://$upstream_bitwarden:80;
        proxy_set_header Upgrade $http_upgrade;
        proxy_set_header Connection "Upgrade";
    }

    location /notifications/hub/negotiate {
```

REFER TO MAXIMUM PC VOL. 25 NO. 1 PG. 56

7 WOT NO SUBDOMAINS?

An alternative to setting up multiple subdomains for each server you want remote access to is to use subfolders—https://domain.com/bw instead of https://bw.domain.com. This is the route to follow if you're using a single dynamic hostname or want a catch-all domain name without worrying about setting up individual forwarding for multiple subdomains through your domain provider's interface.

›› If you choose this option, you'll find plenty of example scripts ("server.subfolder.conf.sample") to look at in the "nginx/proxy-confs" folder.

8 ACCESS PROXY CONFIG FILES OUTSIDE DOCKER

If you plan to stick with the nginx reverse proxy we set up last issue, there's one problem following the tutorial above: There's no convenient "proxy-confs" folder. These have been specially built by LinuxServer to simplify using subdomains and subfolders with nginx.

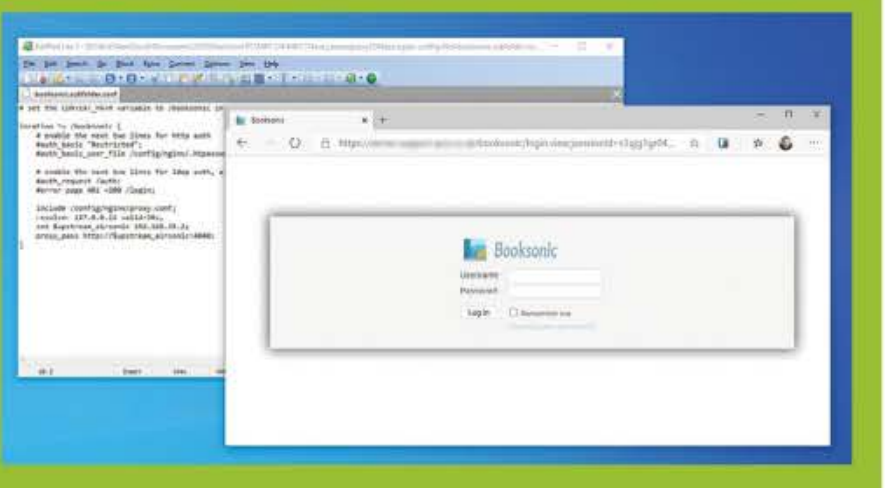
›› Your best bet is to look at the files at https://github.com/linuxserver/reverse-proxy-confs and paste them as individual {server{location}} (subdomains) or {location} (subfolder) blocks into the main "sites-available/default" file. Omit references to "ssl.conf" and "proxy.conf" files and you may be OK—we got Bitwarden_rs working on our Linux-based proxy [**Image C**], but other servers may require additional configuration.

MORE THAN A REVERSE PROXY

Nginx is far more than a simple reverse proxy. As you'll have seen when setting it up, it's also a simple web server—just place your website inside the folder marked as root in the default configuration file (that's /config/www in Docker) and you can serve a website directly from your own network.

You can also use nginx as a load balancer—if you're serving multiple simultaneous connections to one or more servers, or have multiple identical servers and wish to spread the load evenly across them, the {upstream} block is ideal: https://docs.nginx.com/nginx/admin-guide/load-balancer.

Another use for a reverse proxy is to provide a secure connection to insecure resources—that's how the reverse proxy for Bitwarden_rs works. You can do something similar with your Booksonic audiobook server from the Holiday 2019 issue—adapt the airsonic configuration examples; replace "airsonic" with "booksonic" and recreate the container with an additional environment variable (CONTEXT_PATH set to booksonic).



© NGINX

Extract Audio from Video Files

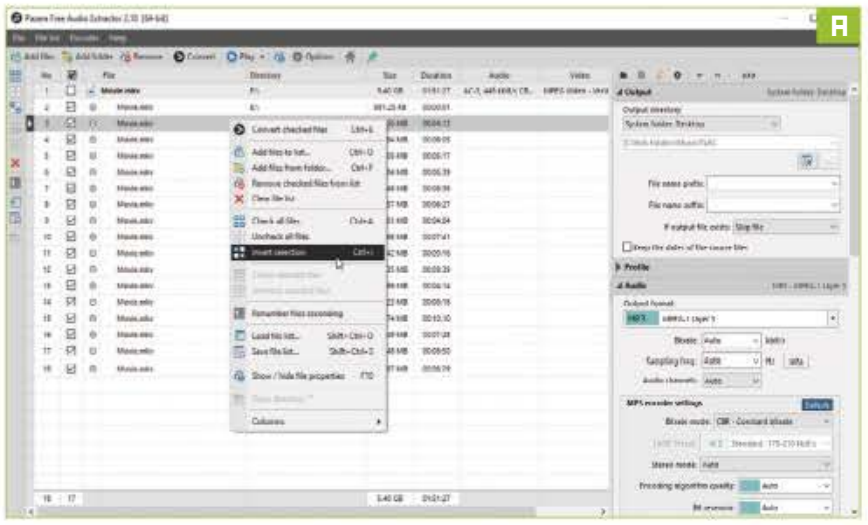
YOU'LL NEED THIS

PAZERA FREE AUDIO EXTRACTOR

Get Pazera Free Audio Extractor, to convert video to audio-only, from www.pazera-software.com. To extract audio from a DVD or Blu-ray, you also need MakeMKV, from www.makemkv.com.

HERE'S THE RUB: There's a great piece of audio you'd like to be able to listen to, like music. Only problem? It's currently embedded in a video, either on your PC, online, or encased in a shiny optical disc. The good news is, armed with the right set of tools, you can convert that audio into a bona fide audio track of your choosing—you get to pick the target format, from MP3 to lossless FLAC, plus add whatever tags you need to help your audio tools identify it correctly.

At the heart of this operation is Pazera Free Audio Extractor, which you'll find at www.pazera-software.com/products/audio-extractor/. It comes in three flavors: 64-bit portable, 32-bit portable, and 32-bit installer. We're using the 64-bit portable version (any excuse to add new apps to our portable tools collection). Pazera enables you to convert both audio and video files to audio from a wide range of files, including the standard MP4 and MKV video formats. Pair it with the right tool (MakeMKV), and you can even use it to extract top-quality audio direct from DVD and Blu-ray, too. Read on to find out how. –NICK PEERS


A

1 RIP AN OPTICAL DISC (OPTIONAL)

If the audio you wish to extract is currently on an optical disc, you first need to rip the track to video—download and install MakeMKV (www.makemkv.com), which works with both DVDs and Blu-rays, and produces an uncompressed copy in MKV format that Pazera can read.

›› After launching, pop your disc in the drive, open MakeMKV, and click the drive icon to read the disc's contents. Next, select the title using its size as a guide (or rip all available titles if you're not sure). To prevent confusion later, expand each title and uncheck all audio tracks except the one you want to keep (typically English). Once done, select a folder on your hard drive, and click the "Make MKV" button to rip it.

2 SELECT TRACKS TO EXTRACT

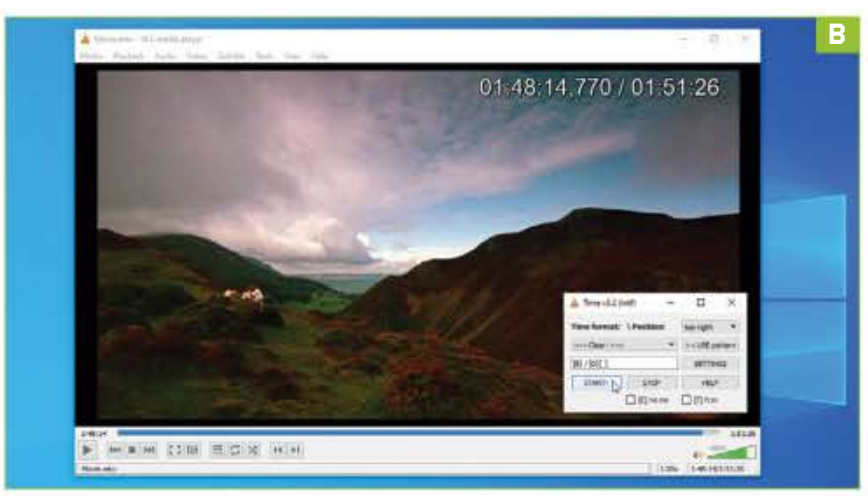
Whether you've ripped a disc or have an existing video file to hand, your next step is to launch Pazera Free Audio Extractor. Click the "Add files" button to browse for and select the video containing the audio you want. If the movie in question is split into multiple chapters, Pazera detects these and lists them underneath the main title—in fact, it goes further, to automatically select each individual chapter instead of the main file, meaning separate audio files are created for each chapter of your movie. If you'd rather extract the complete audio track or want to extract a specific part of the movie, right-click any of the tracks, and choose "Invert selection" or press Ctrl-I [**Image A**] to select the main movie instead of its component chapters.

›› If you want to extract the audio from a specific part of the movie, you need to identify the exact start and end points in hours, minutes, seconds, and (optionally) milliseconds from the start of your movie. To do this, open your video file in a movie player with a timeline slider showing the time—Windows 10's Films & TV movie player goes down to the seconds level, for example. For even finer control, try VLC Media Player (www.videolan.org)—choose "Playback → Speed → Slower" if you're struggling to identify the exact start and end points, and install the Time add-on (https://addons.videolan.org/p/1154032/) if you want to display the current time in milliseconds for more precise selection [**Image B**].

3 SET BASIC PARAMETERS

You'll notice four expandable tabs in the right-hand pane. First, expand "Output" to choose where to save your converted file—click the "Output directory" drop-down to choose a different folder from where the video currently resides. You can also rename the file by adding a prefix and/or suffix to the existing filename—either your own naming convention or click the down arrow to add a time stamp or output format.

›› To quickly choose a preset audio format, expand "Profile" and click the drop-down to reveal a selection of common output formats, from MP3 to WAV, and preset settings based on desired quality. Choose a profile to use as a template for your audio file, then move on.



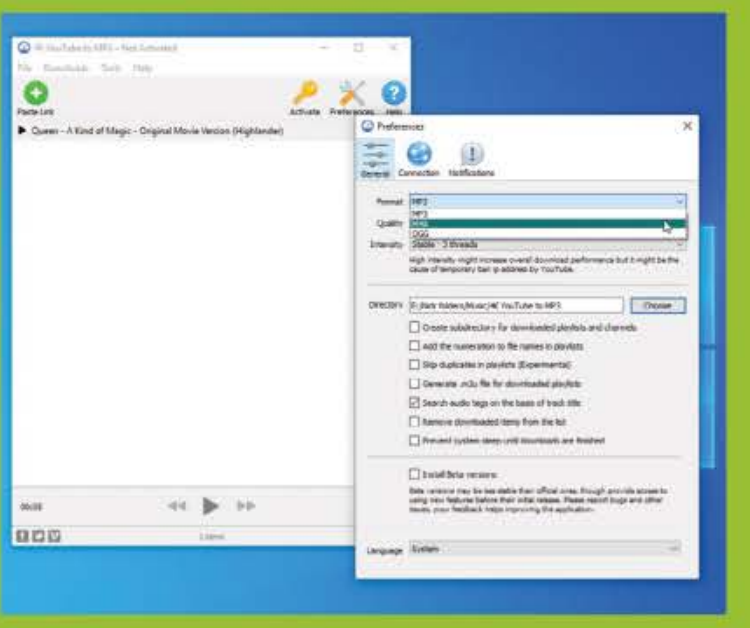
B

© PAZERA FREE AUDIO EXTRACTOR, VIDEOLAN

EXTRACT AUDIO FROM ONLINE VIDEO

Another rich source of audio is online video, and while it's possible to download the video and then extract the audio using Pazera Free Audio Extractor, an even better approach is to install a dedicated tool for downloading and stripping out the audio track in one go. One such tool is 4K YouTube to MP3 (www.4kdownload.com/products/product-youtubetomp3). Despite the name, the program supports a wide range of online sources, including Soundcloud, Vimeo, Facebook, and Flickr, and can convert to OGG and M4A, as well as MP3.

Once installed, launch the program and click "Preferences" to set your chosen format, quality (original by default), and output folder. Then locate the video clip containing the audio you want to extract in your browser, and copy the URL to the clipboard. Now switch back to 4K YouTube to MP3, and click the "Paste Link" button. Sit back and wait for the file to be downloaded and converted.



The 4K YouTube to MP3 interface's minimalism betrays its elegant capabilities—and you're not limited to YouTube and MP3 either.

4 SET ENCODER

Next, expand the "Audio" section. After confirming (or changing) your output format, you need to tweak various other settings—in many cases, the automatic settings can be left alone, but you may want to try different settings (for example, if you're extracting music in a surround sound format that you wish to mix down to a basic two-channel stereo recording).

›› There's a whole section devoted to encoder settings for advanced users—this is something you can return to if your extracted audio file doesn't sound as good as you expect. For now, leave most of the audio settings on auto (one exception might be the "Audio Channels" drop-down menu to set the aforementioned two-channel stereo setting), and scroll down.

›› A volume slider enables you to increase the track's volume (up to 3x the original) or decrease it (choose a number between 0 and 0.99). Start with 1x for now—you can then adjust it later if necessary. Finally, if your video file contains multiple audio tracks, click the "Audio track to convert" drop-down to verify the correct track has been selected.

5 SET TIME OFFSET

Expand the "Additional settings" tab. Here you'll find the offset controls for specifying a start and end point. Either or both can be entered. No start time offset means it extracts everything from the beginning of your movie to the time specified in the "End time offset," while the reverse is also true: Specify a "Start time offset" but not "End time offset" and everything after your start time is extracted into the audio file [Image C].

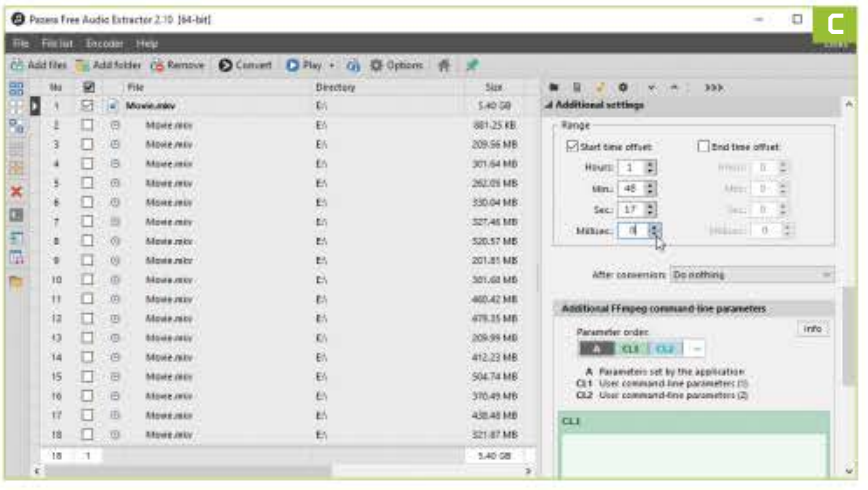
›› Enter your desired figures into the "Hours," "Min," "Sec," and—if applicable—"Millisec" fields, then click the "Play" button at the top of the main window. This starts playback from exactly the moment you specified under "Start time offset," enabling you to verify (and alter if necessary) the point at which your audio file starts.

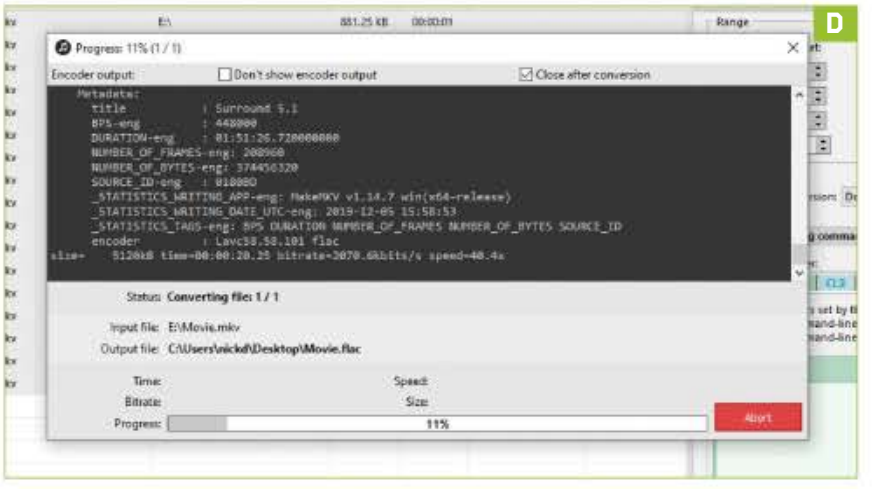
6 EXTRACT YOUR AUDIO AND TEST

Check the settings once more and click "Convert." Your track is extracted in a matter of seconds [Image D]. Now play the extracted audio file to see how it sounds. Too quiet? Use the "Volume Slider" under "Audio" to boost the volume and try again. Sound quality not up to scratch? You may, for example, experience clipping where the volume isn't consistent. Try a different profile setting or dig into the encoder settings, and try non-automatic settings to see what happens.

›› In terms of upping quality with MP3 files, most of the options on show under "Audio" should be largely self-explanatory—in most cases, setting higher figures such as bitrates, bit depth, and sample frequencies will improve things, albeit at a cost of increased file sizes.

›› Finally, the more processing power and RAM you have, the faster the extraction process—our 32GB Ryzen 7 2700 PC extracts audio at about a second for each minute of audio. This makes it practical to experiment with lots of different settings until you've find the perfect audio copy you need.





Track Activity with the Win 10 Timeline

YOU'LL NEED THIS

WINDOWS 10
Instructions for accessing Timeline are below.

YOU'VE PROBABLY MADE USE of the history feature in your web browser to track down a website you've visited previously, but now can't remember the name of. The Windows Timeline is, essentially, a history function for all of your PC activity.

Introduced with the Windows 10 April 2018 Update, Timeline is part of the Task View feature of Windows. As well as enabling you to see a history of the files you've been working on and activities you've undertaken, Timeline can also sync this information between computers.

Timeline provides a chronological overview of what you've been doing on your computer, and gives you a way to pick up from where you left off. It's great to use on a single PC, but cloud synching means you can also pull in your activity on other computers, even your smartphone. Let's take a look at how it all works. –**MARK WYCIŚLIK-WILSON**

1 ACCESS TIMELINE

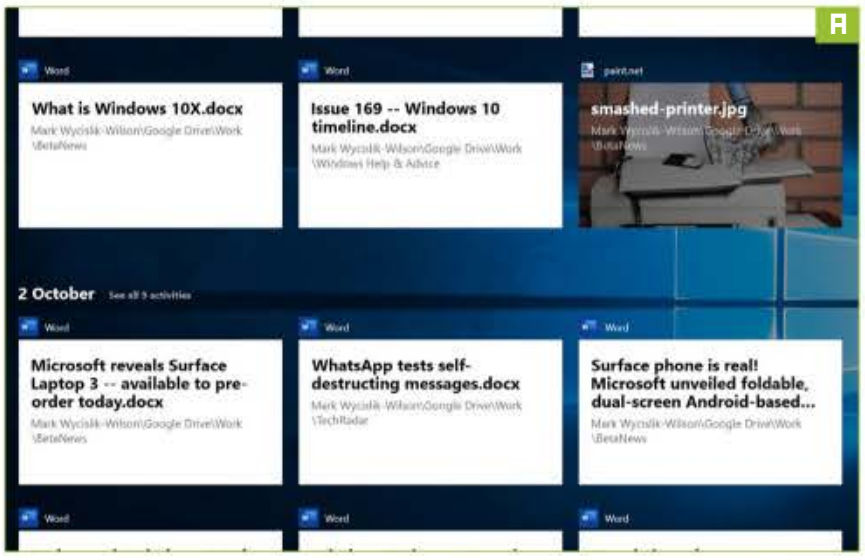
As with so many features of Windows 10, there are several ways in which you can access Timeline. The first and most obvious is to simply click the "Timeline" button on the Taskbar (if this is not available, right-click the Taskbar, and select "Show Task View button"), but you can use the keyboard shortcut Win-Tab, too. If you're using a laptop, you can also use a finger gesture, swiping upward with four fingers.

2 BROWSE YOUR TIMELINE

With Timeline activated, you see a list of things you have worked on recently—the apps you have used, the documents you have created and edited, and the websites you have visited. The simplest way to step back in time is just scroll downward to using your trackpad, mouse wheel, or the scrollbar to the right of the screen, where you will also see a list of dates.

3 VIEW ACTIVITIES

By default, Timeline shows you the "top" activities from any given date [**Image A**], which means that you don't see all of your activity from that day. To rectify this, just click the "See all xx activities" link next to a date, and everything you have worked on that day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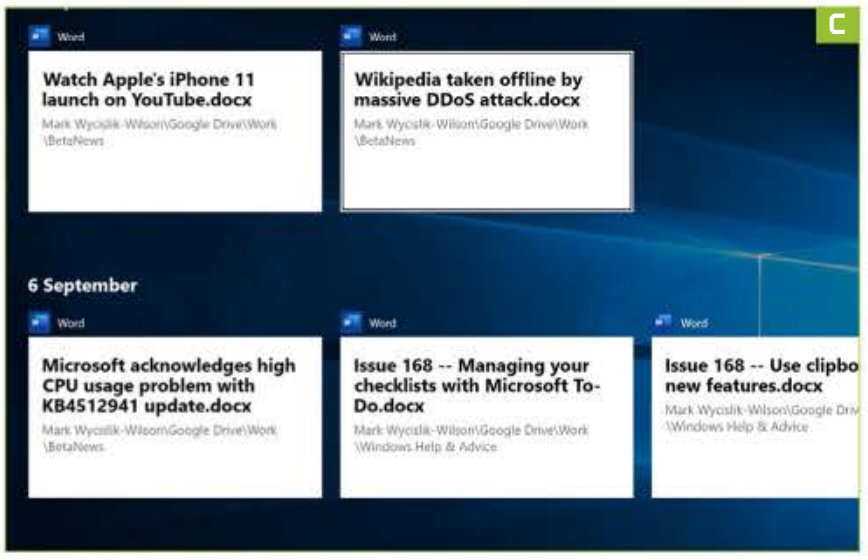
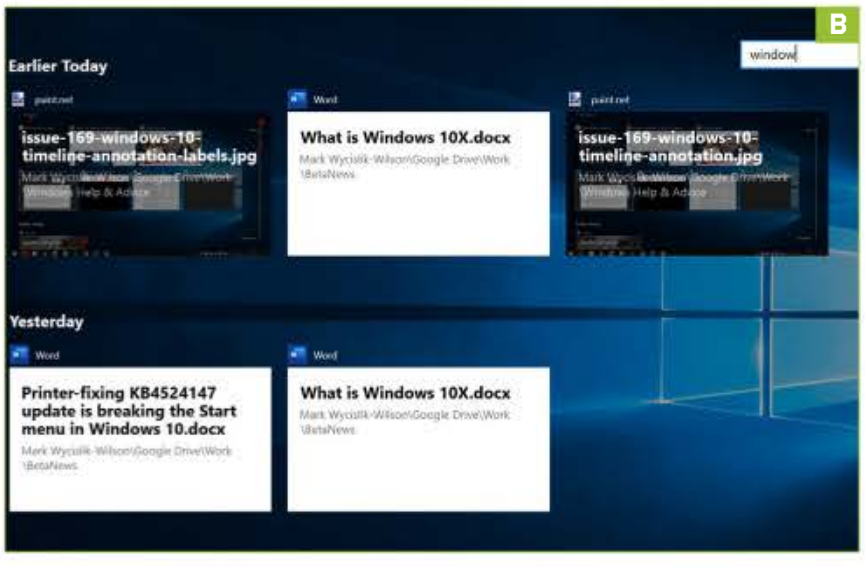
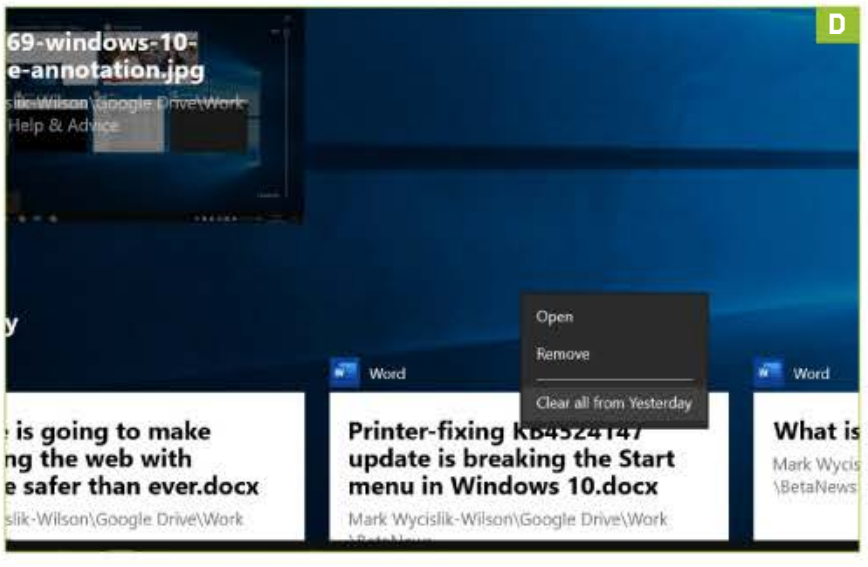
What is Windows 10X.docx
Issue 169 -- Windows 10 timeline.docx
smashed-printer.jpg
2 October
Microsoft reveals Surface Laptop 3 -- available to pre-order today.docx
WhatsApp tests self-destructing messages.docx
Surface phone is real! Microsoft unveiled foldable, dual-screen Android-based...


C
Watch Apple's iPhone 11 launch on YouTube.docx
Wikipedia taken offline by massive DDoS attack.docx
6 September
Microsoft acknowledges high CPU usage problem with KB4512941 update.docx
Issue 168 -- Managing your checklists with Microsoft To-Do.docx
Issue 168 -- Use clipbo new features.docx





© MICROSOFT

expands into view. You can return to the main view by clicking the "See only top activities" link at the top of the screen.

4 SEARCH TIMELINE

Timeline features a useful search option that can be used to track down particular files you have been working on. After calling up Timeline, click the magnifying glass icon to the upper-right of the screen, and type your search term, before pressing Enter [**Image B**]. You can search for file names, the names of folders, or for apps.

5 ACCESS TIMELINE DOCUMENTS

All you need to do to access a document, website, or application from the Timeline is click it [**Image C**]. You can think of Timeline as an extended version of Recent Documents, but unfortunately—for the time being, at least—it only keeps track of the websites you have visited in Edge, so you have to rely on the history option in your particular web browser if you use a different one.

6 REMOVE INDIVIDUAL ACTIVITIES

In the name of privacy, you may wish to remove certain activities from your history. Sadly, there is no way to get Windows to stop tracking particular apps or files. To delete an individual activity, simply call up Timeline, right-click the activity in question, and select "Remove." You can also remove an entire day's activities by selecting the "Clear all" option [**Image D**].

7 CLEAR ENTIRE TIMELINE HISTORY

If you prefer to wipe your entire Timeline history, open Settings, click "Privacy," and then click "Activity history." Toggle the switch relating to your Microsoft account to the "Off" position, then click the link labeled "Manage my Microsoft account activity data." On the Microsoft website, move to the "Activity History" section [**Image E**], click "Apps and services," then the "Clear activity" link.

8 TIMELINE SYNCHRONIZATION

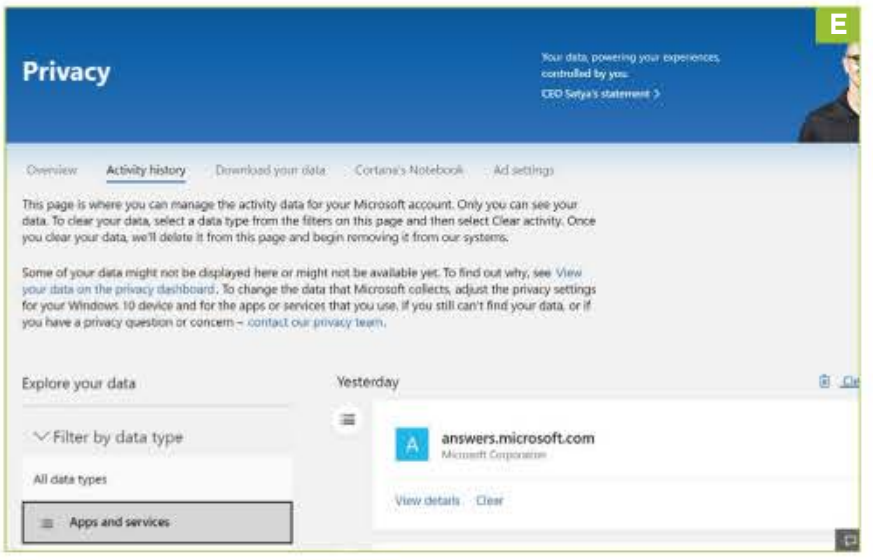
If you use more than one computer, it can be handy to have your activities synchronized, so you can start your work on one PC, then pick it up on another. The first time you open Timeline, you are invited to "See more days in Timeline." You should also have the "Store my activity history on this device" and "Send my activity history to Microsoft" settings enabled in the "Activity history" settings [**Image F**].

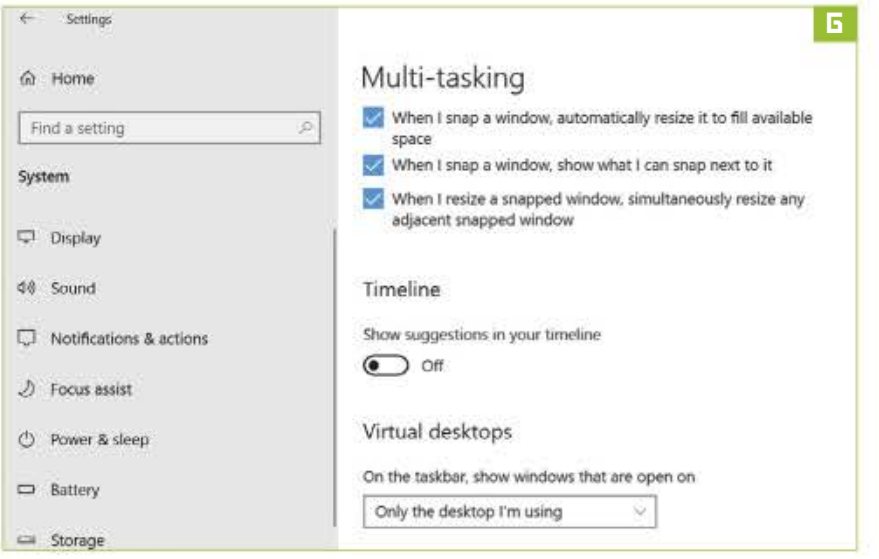
9 SWITCH OFF SUGGESTIONS

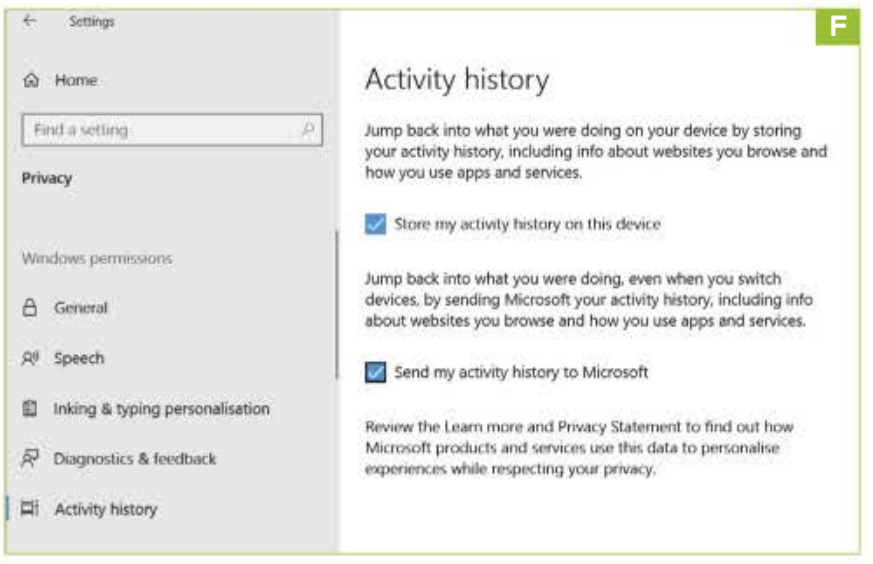
For reasons best known to Microsoft, Timeline occasionally offers you suggestions, which you may well feel are unnecessary. To disable this option, open up Settings from the "Start" menu, and head to "System," before clicking the "Multi-tasking" link to the left. Under the heading "Timeline," move the switch labeled "Show suggestions in your timeline" to the "Off" position [**Image G**].

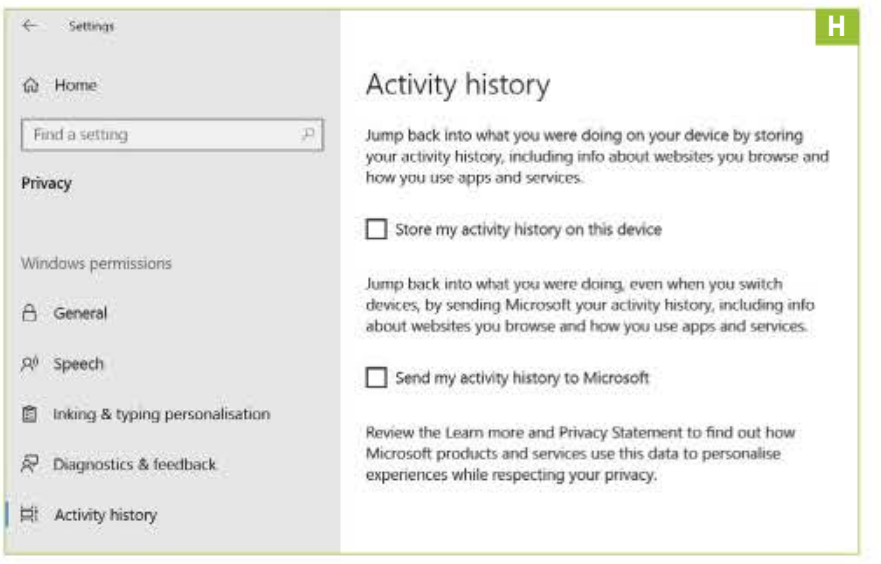
10 DISABLE TIMELINE

As useful as Timeline is, it is not for everyone. To disable it, open Settings, and head to the "Privacy" section. Click the "Activity history" heading to the left, and then uncheck the options labeled "Store my activity history on this device" and "Send my activity history to Microsoft" [**Image H**]. You should also flick the toggle relating to your Microsoft account to the "Off" position.


E
Privacy
Your data, powering your experiences, controlled by you.
CEO Satya's statement >
Overview
Activity history
Download your data
Cortana's Notebook
Ad settings
This page is where you can manage the activity data for your Microsoft account. Only you can see your data. To clear your data, select a data type from the filters on this page and then select Clear activity. Once you clear your data, we'll delete it from this page and begin removing it from our systems.
Some of your data might not be displayed here or might not be available yet. To find out why, see View your data on the privacy dashboard. To change the data that Microsoft collects, adjust the privacy settings for your Windows 10 device and for the apps or services that you use. If you still can't find your data, or if you have a privacy question or concern – contact our privacy team.
Explore your data
Filter by data type
All data types
Apps and services
Yesterday
answers.microsoft.com
Microsoft Corporation
View details
Clear




F
Settings
Home
Find a setting
Privacy
Windows permissions
General
Speech
Inking & typing personalisation
Diagnostics & feedback
Activity history
Activity history
Jump back into what you were doing on your device by storing your activity history, including info about websites you browse and how you use apps and services.
Store my activity history on this device
Jump back into what you were doing, even when you switch devices, by sending Microsoft your activity history, including info about websites you browse and how you use apps and services.
Send my activity history to Microsoft
Review the Learn more and Privacy Statement to find out how Microsoft products and services use this data to personalise experiences while respecting your privacy.


H
Settings
Home
Find a setting
Privacy
Windows permissions
General
Speech
Inking & typing personalisation
Diagnostics & feedback
Activity history
Activity history
Jump back into what you were doing on your device by storing your activity history, including info about websites you browse and how you use apps and services.
Store my activity history on this device
Jump back into what you were doing, even when you switch devices, by sending Microsoft your activity history, including info about websites you browse and how you use apps and services.
Send my activity history to Microsoft
Review the Learn more and Privacy Statement to find out how Microsoft products and services use this data to personalise experiences while respecting your privacy.

Machine of the Month: the Commodore 64

YOU'LL NEED THIS

VICE (THE VERSATILE COMMODORE EMULATOR)
Download from http://vice-emu.sourceforge.net for your Windows or Linux PC.

WITH A MANUFACTURING LIFESPAN of 12 years, the Commodore 64 is one of the most popular computers in history, with an astonishing library of games, business apps, and multimedia demos. However, this is not simply an old games console. For most software, you can't just press the On button and get started—there are machine quirks to contend with, command prompts to learn, and multiple storage formats to master. So, how do you even get started?

We will show you how to emulate the machine and hit the ground running with the best choice of emulator, how to get your virtual Commodore optimized before gaming, how to load software, and where to find it. Along the way, we'll explore the history of the Commodore 64, with its clever choice of hardware, legendary gaming scene, and expansion into the worldwide market. We'll examine the machine's death and resurrection, following the shift from the booming American market of the '80s to the European budget gaming scene of the '90s, and explore the boutique industry that keeps the Commodore 64 running today. –JOHN KNIGHT

1 BIRTH

The Commodore 64 (or "C64") was a powerhouse computer that reflected the bullish aggression of the company's CEO, Jack Tramiel. Although somewhat expensive on launch, Tramiel took the machine on an all-out price war that would win its place as the best selling computer of all time.

›› Named after its 64KB of RAM, the Commodore 64 was designed to be a great games machines from the outset. At its heart was a MOS 6510 CPU—a variant of the trusty MOS Technologies 6502. Despite being technically slower than much of the competition, it was easier to program than Z80 computers, and custom chipsets powered functions separately from the CPU.

›› Graphically, the powerful VIC-II chip gave the Commodore 16 colors, multicolor hardware sprites, smooth scrolling, and an impressively high resolution for its time. The SID sound chip was developed by an actual musician, Ensoniq's Robert Yannes. Unimpressed with the primitive state of computer audio, Yannes designed a chip that wiped the floor with the competition, and is still used for certain musical applications today—there are even live C64 cover bands!

›› Commodore's choice of hardware for its budget hit a sweet spot that punched well above its weight. By prioritizing gaming, the C64's hardware enabled users to have graphics and sound head and shoulders above the competition, quickly establishing the Commodore as the gaming computer of choice.

›› Most notable was its use of hardware sprites. That may mean little nowadays, but in modern terms, the difference is a bit like having a dedicated graphics card rather than just onboard video. While other machines may have had more RAM or better BASIC, their screens had ugly tearing, color clashes, or inferior audio through cheap sound chips.

2 TAKING CARE OF BUSINESS

Commodore's market dominance and cheap price also gave it a healthy business market. Why pay thousands for an Apple or IBM PC when you could spend a few hundred on something that just uses a television?

›› Although American audiences had moved on by the late '80s, the C64 enjoyed a European resurgence in the early '90s, where it was sold as a budget games machine, winning more users than Nintendo's Entertainment System in many areas. Despite Commodore's eventual bankruptcy in 1994, Eastern Europeans kept using C64s until the late '90s.

›› The Commodore's ubiquity has guaranteed its place in the retro scene, where it is one of the most popular collector systems. Not only did it receive a "Mini" remake in 2017, but the last decade in general brought renewed support. Not only was there new hardware, such as upgrade boards and SD card readers, but new commercially available software is still being written for the platform by indie publishers, such as 2017's *Planet X2* from YouTube's The 8-Bit Guy.

3 HOW TO EMULATE

Our main choice of emulator is VICE. This is the most maintained project with very accurate emulation, and many recent improvements have been made to the interface. VICE supports Windows, Linux, MacOS X, and a range of obscure platforms. VICE not only emulates the C64, but also supports other Commodore machines, such as the Pet, 128, and VIC-20.

›› For the Windows version, head to http://vice-emu.sourceforge.net and download the latest build. Most of these files use the 7zip format, so you may need a separate application for that. VICE doesn't come with an installer, so after extracting the package, you'll have to

›› The C64 had a massive public-domain demo scene, where coders would push the machine to its absolute limits.

© BOOZE DESIGN

Commodore 64 MicroComputer
High Resolution & Sound Synthesizer · Alta risoluzione grafica e sintetizzatore di suoni
commodore COMPUTER
Commodore 64 MicroComputer
High Resolution & Sound Synthesizer · Alta risoluzione grafica e sintetizzatore di suoni

›› There have been numerous C64 recreations—is there an original model lurking in your attic or garage?

go into the folder and manually open x64.exe—you might want to make a desktop shortcut!

›› For Linux users, VICE is available in the repositories, but is probably missing key files (chiefly its "kernal" file) because of licensing restrictions. You can get these files from a source tarball, but it's easier to install a Snap or Flatpak package. Both versions should install entries in your system menu. Snap users can find the package on the Snapcraft store (free) under the name vice-jz. If you prefer Flatpak, install VICE with the command:

```
$ flatpak install flathub net.sf.VICE
```

4 USAGE

Before you get started on any games, define how you will use joysticks—whether they be keyboard emulated, or by a proper external device. From the system menu, choose "Input devices → Joystick settings." You really need two ports; most games use joystick port 2, so whatever you intend to use most, set that keyset or joystick to use port 2, and have your backup on port 1. Save your configuration via "Settings → Save settings."

›› Although cartridges were available, most C64 software came on tape or disk, which will be in T64 or D64 file format. The easiest way to load something is by clicking "File → Smart attach disk/tape." Choose your file and click "Attach." VICE now automates all the usual loading processes, entering the BASIC commands for you. If you get stuck at a BASIC prompt saying "LOADING, READY" with a blinking cursor, try typing "RUN" and pressing Enter.

5 ALTERNATE OPTION: CCS64

Windows users might consider trying CCS64 (http://ccs64.com), which is an older emulator with cool tricks and hacks you won't find elsewhere, such as shortcuts for BASIC. There are newer versions for modern Windows using DirectX 9.0, older versions that work on DOS, and a very old version for Linux (good luck getting it working now). CCS64 isn't the most intuitive of interfaces and is primarily keyboard-driven. F11 and F12 are quick load and quick save, which you'll use a lot. On the plus side, it's very easy to forget you're using a PC, because the interface is highly immersive, feeling almost 8-bit itself.

FIND SOFTWARE

Stretching from 1982 to today, the Commodore 64 library is colossal. Obviously, there are ROM and abandonware sites—and pretty much any site will do—but we can't endorse these for legal reasons. Archive.org has plenty of software to choose from (some of which will even run in your browser), and C64.com is an invaluable resource with more software than you could ever hope to browse.

The C64 had a strong magazine scene, which came with coverdisks and tapes. These were packed with multimedia demos, game demos, and even full games. Coverdisk and covertape archives are a great source for software, cataloged through the years and documented in magazine issues.

If you fancy buying new software for the system, there are numerous indie labels selling new titles for the C64, including Psytronik Software (www.psytronik.net), Protovision (www.protovision.games), and Doublesided Games (http://doublesidedgames.com). Modern highlights include *Organism* (2015), *Sam's Journey* (2017), and *Farming Simulator—C64 Edition* (2018).

SPECIFICATIONS

COMMODORE 64 (1982)

CPU:	MOS Technology 6510 @ 1MHz
RAM:	64KB
Launch Price:	$595
Graphics:	320x200, 16 colors
Sound:	SID 6581
Storage:	Cassette, 5.25-inch floppy, ROM cartridge
OS:	Commodore Kernal/Basic 2.0
Released:	August 1982
Production:	1982–1994
Worldwide sales:	17 million

›› American Commodore fans should explore '90s European titles, which stretch C64 gaming to near 16-bit levels.

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Lay Out Pages in Affinity Publisher

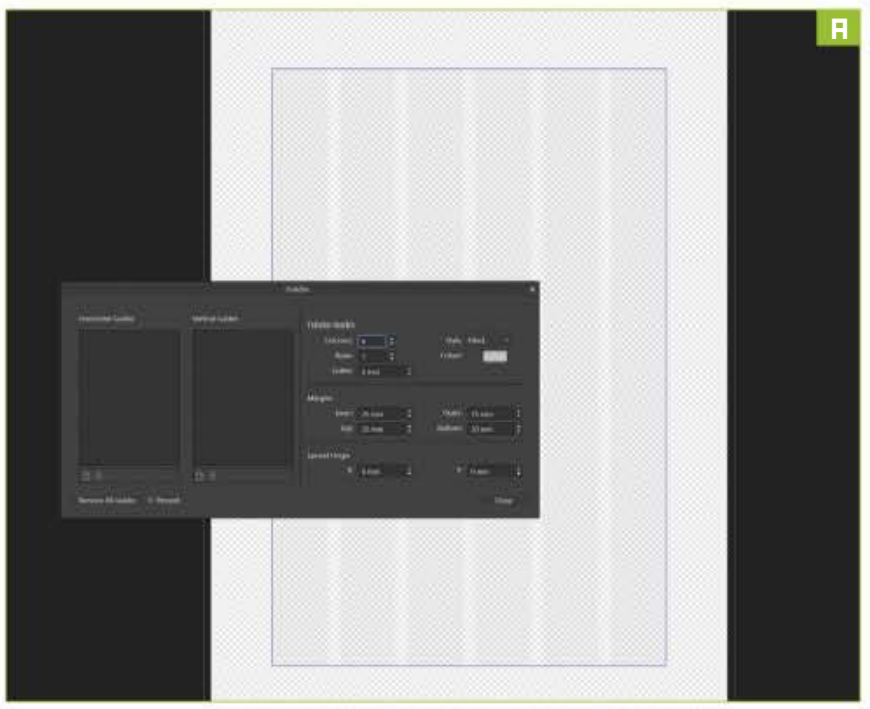
YOU'LL NEED THIS

AFFINITY PUBLISHER
See https://affinity.serif.com to find out more.

NOW THANKSGIVING AND CHRISTMAS ARE OVER, chances are there are a lot of copies of the Affinity apps freshly installed on hard drives across the nation. If that sounds like your situation, and you took advantage of the discounts offered in the end-of-year celebration of spending, you may be wondering just what to do next.

Getting started in Affinity Publisher doesn't have to be terrifying. To get the best results, it's worth putting some time into the setup of your documents, but once that's done, the hard work of placing image and text frames is rendered easy by the software. Here, we'll cover creating a new document, setting up guides, and importing image and text files. We'll split a text frame into columns, and link two together so the text flows from one to the other. We'll also switch to the Photo persona for a bit of quick and dirty image editing, too.

This only scratches the surface of what Publisher, and the entire Affinity suite, are capable of. But if you can get the basics right, the chances are greater that you'll produce the kind of documents you want to see, and get them properly printed, too. **–IAN EVENDEN**



1 A NEW DOCUMENT

Once you've got Publisher running, start a new document with "File → New," or by clicking "New Document" on the Welcome screen. You get a lot of options, including the paper size you want to print on, the measurement units and color system it will use, the margins (check with your printer), and whether image files are linked to (smaller file, greater risk of something getting lost) or embedded in the document (greater safety, enormous file). Once you're happy—and it's worth taking your time, especially if you're outputting to a commercial printer—hit "OK."

2 GUIDES

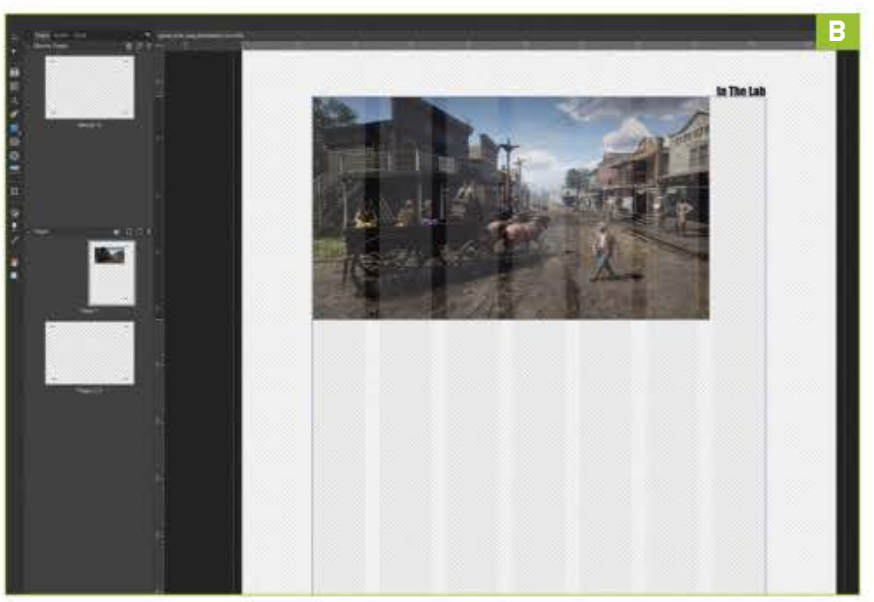
Underneath each document is a framework that will stay the same from one page to another, perhaps throughout your entire publication. Open the Guides Manager from "View → Guides Manager," and set up what graphic designers like to call a "grid" [**Image A**]. It's not a grid, it's a series of columns, but that's designers for you. A common number of columns to put on a page is seven, as this allows for three columns of text, plus an extra bit you can use for a narrow boxout or bit of artwork. We've set up a seven-column layout, with 5mm gutters between them.

3 HEADERS AND FOOTERS

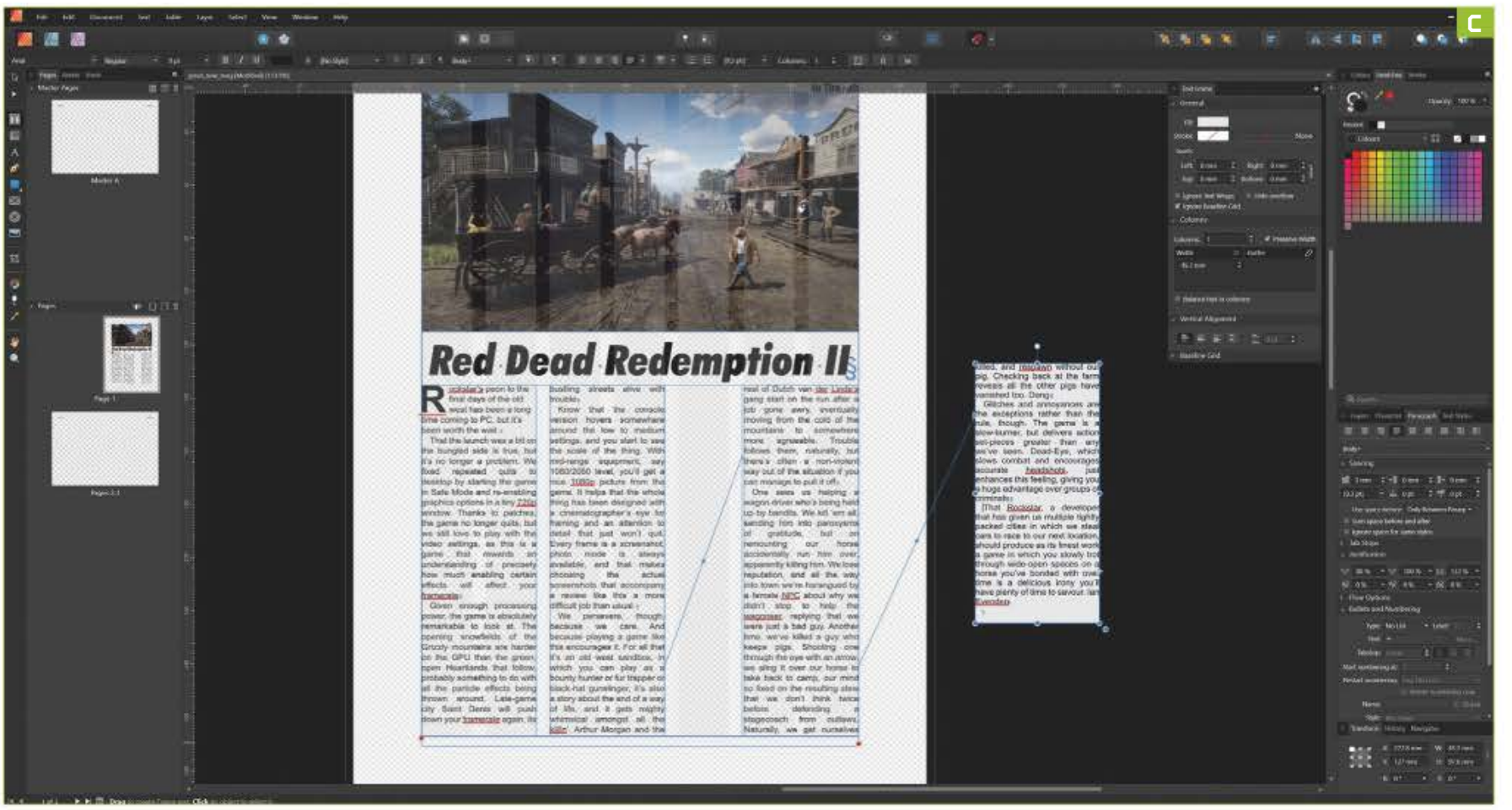
Look up. Now look down. At the top of this page is a header, with the name of the section—"R&D"—and a representation of how far through you are. At the bottom is a footer, with the page number, name of the magazine, and date. All magazines are different, and these aren't the most exciting parts of a page, but they are important for reader navigation. Page numbers go on the exterior edge of the pages, and headers and footers mirror each other across spreads, so you need to create them differently depending on whether you're on a left or right-hand page. Do this on the Master A page, in the Pages palette, and you can add it automatically to every page you create.

4 FRAMES

In Affinity Publisher, everything lives in a frame, and each frame lives on its own layer in the Layers palette. Knowing how large the frames should be is a bit of an art, so let's start with something with a fixed aspect ratio—a screenshot [**Image B**]. This will be 16:9, and fitting it to the width of the page gives us its height. Select "File → Place," navigate to your image files, and choose one. Your cursor changes to an arrow—this is



© SERIF LTD



loaded with your image file, and you can drag a frame on the page to house it. Make sure the magnet icon at the top center-right of the interface is selected; this makes your cursor stick—or "snap"—to the guides on your page. Drag out the frame from the top-left, and the aspect ratio should be preserved, meaning it won't be distorted. Make it the full width of the page. If you need to adjust it, use the black arrow tool (Move) on the drag handles.

5 TEXT

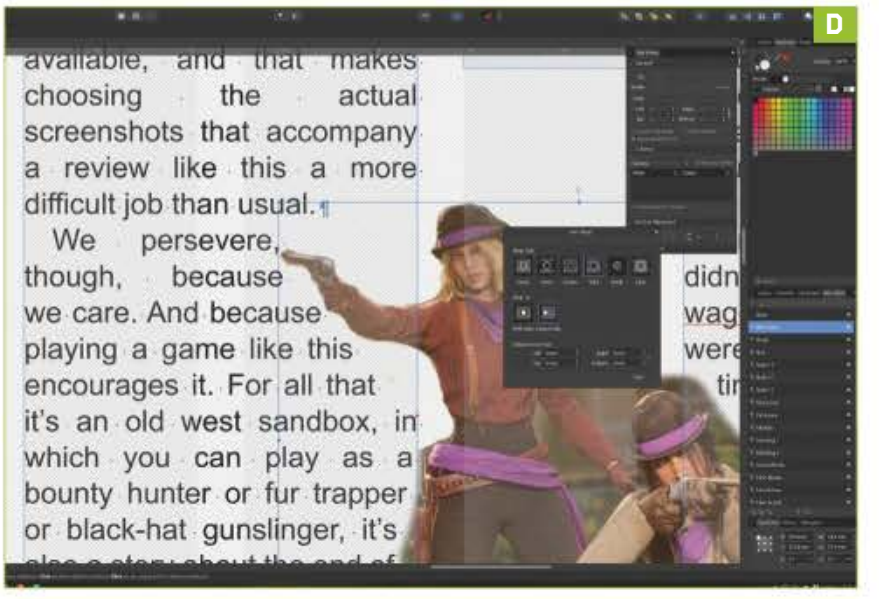
Adding text is similar to adding images, but you should set your frames up beforehand [**Image C**]. The headline runs the full width of the page (this isn't always the case, but this is a simple single page), so drag out a text frame (don't confuse the Text Frame and Artistic Text tools) large enough to hold your text in a font and at a large enough point size that will be consistent across your publication. Below, the body text goes in a (usually) different font, and a much smaller point size. The seven-column grid comes in handy, allowing a spare column we can pop a bit of artwork in later, so we've got two text frames creating three equal-width columns of text covering six of the seven columns. We've linked them so the text flows from one to the next, using the triangle that appears on the edge of the frame. Use "File → Place," or copy and paste, to import your text.

6 THAT EXTRA COLUMN

Cutout artwork is a staple of the magazine trade, making pages look good since the days of QuarkXpress (which, before we get letters, is still going strong on version 2019). Affinity makes it easy—import a picture as you did before, and size the bit you want to fit the column. If it doesn't already have a white background, or something convenient like an alpha channel or embedded path you can use, flip into the Photo persona (you need Affinity Photo installed), and use the Erase brush to remove the bits of the image you don't want. We're left with a revolver sticking out into our text, and we can flow the text around it using "Text Wrap" back in the Publisher persona [**Image D**]. Set it to wrap to the "Largest Side," otherwise it tries to insert words in every tiny gap. You could also use this space for a caption, or for laying out the recommended specs for a PC game. There you have it: a simple magazine page.

MORE COLUMNS

If you're wondering how wide your columns should be, consider how easy they are to read. More than 80 characters across is too many; around half that many is more usual. In newspapers, thicker columns are often used to denote more important stories, but magazines tend to be more consistent, keeping the same widths, and text sizes, throughout a section, if not the whole issue. Long columns can also be tiring to read, so break them up by using a pull quote—a sentence from the text that's particularly important placed in its own box in a larger text size. This also serves to draw a reader's attention to the article if they're just flicking through.


available, and that makes
choosing the actual
screenshots that accompany
a review like this a more
difficult job than usual.
We persevere,
though, because
we care. And because
playing a game like this
encourages it. For all that
it's an old west sandbox, in
which you can play as a
bounty hunter or fur trapper
or black-hat gunslinger, it's

BUILD IT

CHRISTIAN GUYTON, STAFF WRITER

My First PC

A simple, affordable computer, ideal for beginners setting out on their system-building journey

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

IF YOU'RE A SEASONED PC BUILDER, this might not be the build for you. We're just being honest; this is a straightforward build, the perfect PC for a novice tech head looking to build their first rig. We've made the instructions simpler than usual, and this system has as few cables and components as we could manage. Within reason, of course: We want this to remain a capable home PC, with a bit of gaming and workstation potential, at a sensible price point, so we're still including a GPU and a case with some RGB lighting.

The goal is to help you—or your PC-assembly-challenged pal—put together a functioning computer while also learning the basic building blocks of what makes a PC. Obviously, we have limited space to do this, but if you're ever uncertain of what goes where, don't be afraid to leaf through the manuals of each component. If you don't know your GPU from your PSU, you might want to take to Google for each step, to make sure you've got the right hardware.

While we have a list of specific ingredients for this build, don't feel compelled to stick to it. Some of the components here (notably the GPU and SSD) were chosen to keep the price down, so higher-spec components there wouldn't go amiss. We do advise against swapping out the CPU and motherboard for this build, though, to keep compatibility problems at bay.

This build should teach any rookie the fundamentals of PC building. If you're new to the ancient art of custom system building, or have a friend who's eager to build their first PC but doesn't know where to start, look no further.

KEEPING IT CLEAN

WE'RE A BIG FAN of the case we're using: the Enso Mesh in white from BitFenix. It's 80 bucks, and comes with a tempered glass window panel and some subtle but aesthetically pleasing RGB lighting on the front. The front I/O is a little plasticky, but for under 100 dollars, it's hard to argue with the quality of this case.

The motherboard is an Asus ROG Strix X470-F Gaming, a standard mobo with all the hardware we need for this easy build. The X470 chipset is ideal for our CPU, a last-gen AMD Ryzen 5 2600. Yes, we could have chosen a superior third-gen Ryzen chip without making this build any more complicated, but the second-gen components are relatively cheap right now and have better overclocking potential for builders who want to experiment. The Ryzen 5 2600 comes with an AMD Wraith Stealth air cooler, too.

For RAM, we've got a two-piece kit of Corsair Vengeance LPX memory, which runs at 3,000MHz. Graphics are handled by another AMD piece, the Radeon RX 580, specifically Sapphire Tech's factory-overclocked 8GB Pulse model. The RX 500-series GPUs are great value at the time of writing, but the stock is swiftly drying up, and soon it might be better to opt for a newer RX 5500 or 5600 XT instead, provided you stick with the 8GB models.

All this is powered by a Corsair CX450 power supply, an excellent and affordable PSU that might not have modular cable design but doesn't have a heap of non-removable cables to clutter the build.

The final piece of this puzzle is a Crucial P1 1TB M.2 SSD—a little drive with a lot of storage space. There's room for additional drives in this build, but we're keeping it simple with an M.2 drive; no need for connecting cables and chunky hard drives here. And as always, we'll cap this build off with an install of Windows 10 Home, which costs a round 100 dollars.

INGREDIENTS

PART		STREET PRICE
Case	BitFenix Enso Mesh	$80
Motherboard	Asus ROG Strix X470-F Gaming	$80
CPU	AMD Ryzen 5 2600	$120
CPU Cooler	AMD Wraith Stealth	N/A
Memory	16GB (2x 8GB) Corsair Vengeance LPX @ 3,000MHz	$65
GPU	Sapphire Radeon Pulse RX 580 8GB	$190
PSU	450W Corsair CX450	$50
SSD	Crucial P1 1TB	$100
OS	Windows 10 Home 64-bit	$100
Total		$785

1 SANS FANS

AS IS CUSTOM, we get cracking with a full case stripdown. Remove the window pane and metal side panel (the latter of which is secured with thumbscrews, although these may require a bit of persuasion from your screwdriver first), and then set them aside along with the magnetic dust filter on top of the case. Be sure to use a bowl or pot to keep all the screws you're working with in one place. Lastly, you need to remove two of the small blanking plates from the rear of the case, to make room for the graphics card's rear I/O—specifically, the second and third plates from the top of the case. That's all you need to do for now; shift the case out of your working space, and we'll move on to the motherboard assembly.

2 ANTISTATIC ACTION

UNLESS YOU HAVE A dedicated workbench, unpack your motherboard and place it on top of the box it came in. The antistatic bag it arrives in only reduces static buildup on the inside; don't rest the board on top of the bag, or you're liable to get a little shock. With your mobo unpacked, release the clips on one end of the memory slots, and push your two sticks of Corsair Vengeance LPX RAM into the slots marked A2 and B2, making sure that they click into place. Slot the Crucial P1 M.2 drive into the M.2 slot and screw it down to the tiny silver stand-off with a small Phillips head screwdriver. You also need to remove the rear RGB case fan, as it'll get in the way later on. Simply unscrew it from the back of the case and set it to one side, reinstalling it after the motherboard is mounted.

3 HEAT MANAGED

THE CPU NEEDS TO BE INSTALLED next. Lift up the metal retention arm, then drop the CPU into place in the socket, lining up the gold triangle in the corner with the triangle on the socket. If you bought your motherboard new, there is likely a pair of plastic brackets screwed down either side of the CPU socket. Unscrew these, but leave the metal cooler backplate attached, so that the screw stand-offs poke through the four holes around the CPU. Apply a pea-sized blob of thermal paste to the metal top of the processor, then take the CPU cooler and place it over the CPU, so the four spring-loaded screws line up with the cooler plate's stand-offs. Screw it down. Next, plug the cooler's power cable into the four-pin connector on the motherboard labeled "CPU_FAN."

4 POWER UP

THE LIMITED SPACE for cable routing in this case means we're installing the PSU before the motherboard. Fit the PSU at the rear of the case and screw it down using its four black screws. You need four cables for this: the large ATX motherboard power cable, the eight-pin CPU power cable, the two-parter PCIe power cable for the GPU, and one accessory cable with a long thin L-shaped connector. The rest can be folded and tucked into the hard drive cage next to the PSU. Feed the mobo and GPU cables into the main case cavity, through the two rubber-sealed holes in the chassis, then the CPU power cable through the hole in the top-rear corner of the case. Untie the cables from the case's front I/O, and connect the RGB power connector to the accessory cable from the PSU.

5 MEXICAN STAND-OFF

YOU NEED TO INSTALL three new silver stand-offs for the mobo. These are included with the case; you need nine stand-offs in three rows. Now lower the motherboard into the case, making sure the rear I/O is lined up, then use nine of the black motherboard screws to secure it. Feed through the front I/O cables and plug them into the connectors on the mobo, along with the ATX and CPU power cables (use the mobo manual if you're unsure which cable goes where). Fit the GPU to one of the long PCIe slots, so that its rear I/O lines up with the two blanking plates we removed. Open the clasp on the PCIe slot before inserting the GPU's connector; it should lock into place, and can be secured to the rear of the case with two screws. Plug in that final power cable to the GPU.

6 CABLE CAPERS

THE REAR OF THIS CASE has several locations to clip cables to, using cable ties to secure them. Try to route slack cables behind the motherboard in neat, flat lines, snipping off excess lengths of the cable ties with scissors (be careful not to cut any cables). You also need to plug in the two case fans, using the other four-pin connectors on the mobo, connecting the rear fan's RGB controller to the little PWM fan hub screwed on to the case behind the motherboard. Some of these cables can't be neatly routed, so just tuck any cable slack out of sight from the case window. If you don't have anywhere to secure a cable, you can bundle it and tie it off to itself to tidy things up. Once your case looks as neat as it can be, replace the side panel and window, and screw them on. Job done!

1 **The rear case fan looks pretty good, with simple RGB lighting that syncs automatically with the lighting on the front of the case.**

2 **This RX 580 is a bulky card, so make sure that it's well screwed down to the rear of the case; the PCIe slot locks into place, but it doesn't support the weight of the GPU.**

3 **Our sole drive here is an M.2 SSD, the only kind of drive that is installed directly to the motherboard. SATA SSDs and HDDs must be installed elsewhere in the case, then connected to the motherboard via a SATA cable.**

EFFECTIVE, BUT NOT TOO COMPLEX

PERFORMANCE-WISE, this build didn't quite live up to our expectations. The Radeon RX 580 GPU is still functional, but AMD's 2020 update to its Adrenalin software actually makes the gaming performance slightly worse. The Crucial P1 M.2 drive also failed to meet expectations, although it's worth remembering that both components were fairly cheap—if you've got more cash, we advise replacing them with newer parts.

The Ryzen 5 2600 CPU worked well, assuaging any concerns we had about using a second-gen Ryzen instead of a newer Ryzen 3000-series chip. Yes, this build might not be as future-proofed as it could be, but there's no complicated BIOS meddling to be done. Using a third-gen processor would also have demanded use of an X570-chipset motherboard, which would have brought the price up further. The Wraith Stealth cooler included with the 2600 also did the job; while all-in-one liquid coolers are nice, AMD's stock coolers are effective, and ideal for beginners, thanks to their simple design.

We wouldn't change the RAM or power supply either; if you're able to find comparable models for cheaper, by all means save yourself some cash, but the components we used worked well and required minimal adjustment. The 3,000MHz memory did require use of the motherboard's automatic memory overclocking, but this was as simple as hopping into the BIOS's EZ mode and turning on the clearly marked D.O.C.P. profile for 3,000MHz functionality.

Was it an easy build? Yes. The BitFenix Enso Mesh could use a few more holes in the frame for cable routing, but if you take the time to pre-install your PSU and prep your cables, you shouldn't have any trouble. The case looks great for $80, too.

There were a few moments when we fell afoul of our own fat fingers. The case didn't really give us any grief, but plugging the CPU power cable and front I/O connectors into the motherboard was awkward. Use the motherboard manual to check you're putting everything in the right place, and with a bit of care, you shouldn't have too many problems.

This is a straightforward build, achievable by even the greenest tinkerer. We would encourage more experienced builders to make changes as they best see fit, but rookies are probably best following this guide to the letter, and only swapping out a few components if price permits. You can now build a capable but affordable first PC, and take our lessons with you to build a more advanced system in the future.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	959	1,257 (31%)
CrystalDisk QD32 Sequential Read (MB/s)	3,442	1,599 (-54%)
CrystalDisk QD32 Sequential Write (MB/s)	1,706	1,470 (-14%)
Rise of the Tomb Raider (fps)	95	76 (-20%)
Total War: Warhammer II (fps)	55	42 (-24%)
Tom Clancy's Ghost Recon Wildlands (fps)	48	40 (-17%)
3DMark: Fire Strike (Index)	9,128	12,698 (39%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB Crucial Ballistix Sport LT @ 2,666MT/s, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD. All tests performed at 1080p at the highest graphical profile.

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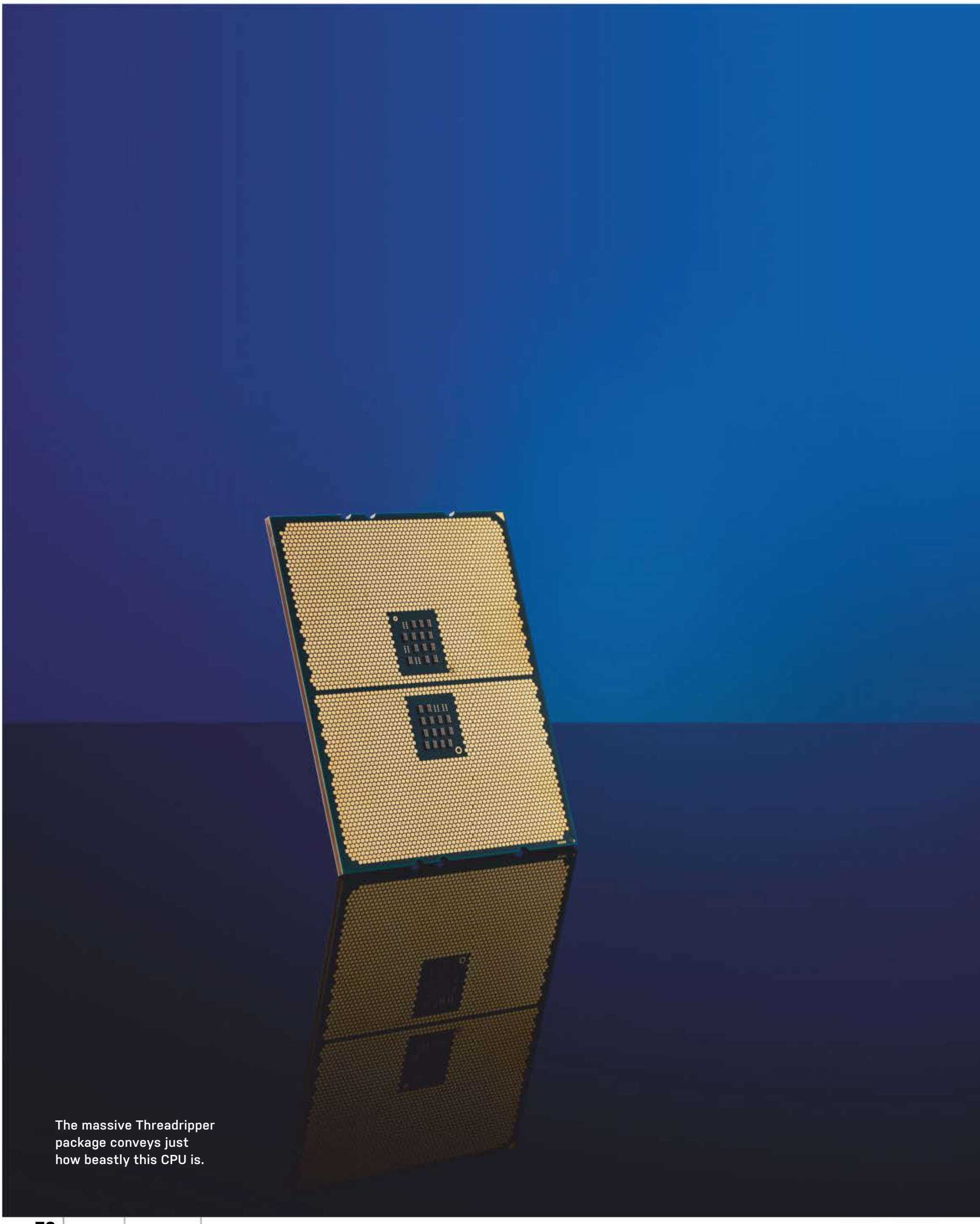


The massive Threadripper package conveys just how beastly this CPU is.

AMD Ryzen Threadripper 3970X

Third-generation Threadripper is the new king of cores

MY NAME IS JARRED, and I have a problem: I'm addicted to extreme hardware. Show me the latest shiny new tech, and I can't help but feel giddy. Today might be too much for my aging body, as I'm about to quadruple the number of cores and threads relative to my everyday work PC. AMD has thrown down the gauntlet with the third round of Threadripper, delivering many of the fastest benchmark results I've ever seen.

Intel's response is telling. It slashed prices on its 10th-gen Cascade Lake-X parts. It's still not enough—at least, not if you're after maximum multithreaded performance. AMD and Intel have now swapped positions in terms of pricing, with the Threadripper 3970X occupying Intel's former two-grand slot. At least the platform and hardware justify the cost.

WARP SPEED

At times, the performance of the 3970X is mind-blowing. Anyone dabbling in 3D rendering will love how fast it is. Cinebench completes its baseline test in a matter of seconds—we remember waiting several minutes just a few years ago on some PCs. The same goes for other tools, such as Blender, Corona, and POV-ray. Other multithreaded tasks start to hit the limits of scaling, however. Video editing is faster than on a 16-core Ryzen 9 3950X, but nowhere near twice as fast. Software development with large projects should benefit, though, as should several other professional applications.

AMD's new TRX40 platform makes some noteworthy changes to help with scaling and performance. Inside the latest Threadripper and Ryzen CPU packages are multiple "chiplets." The CPU chiplets contain two core complexes with four cores each, while the IO chiplet hosts all the logic for communicating with DDR4 memory, PCIe devices, USB ports, and more. AMD can put multiple CPU chiplets into a single package—up to eight (64 cores) with Threadripper 3000. Yes, AMD is planning on releasing a 64-core/128-thread 3990X processor.

Moving the memory controller into the IO chiplet means memory access speeds should be more uniform this round. AMD also links the CPU package and chipset with a PCIe x8 connection, and upgrades the interface to PCIe Gen4, giving it four times the bandwidth between the CPU and chipset compared to other CPUs. The only potential drawback is that this means third-generation Threadripper had to ditch backward compatibility—you can't put a 3970X into an X399 motherboard.

Depending on the app and workload, 3970X is either thread and shoulders above the competition, or it occasionally stumbles. Gaming performance is mostly OK, but several games seem to get confused by the deluge of cores and threads. *Far Cry 5*, *Metro Exodus*, and *Total War: Warhammer 2* all perform worse than a Ryzen 9 3950X (or even a 3900X), but seven other games we tested tied. General performance, measured by PCMark 10, is also worse than a Ryzen 9 3950X, and Handbrake H.265 1080p encoding is only 12 percent faster, despite having twice the cores to work with.

Much like *Field of Dreams*, we believe if you build it (Threadripper), they (apps) will come. Ten years ago, the fastest PCs had four-core CPUs. Ten years before that, the only PCs with more than a single CPU core were multisocket servers. What will PCs look like 10 years from now? Today's Threadripper might seem tame.

Not everyone needs a 32-core monster CPU, but if you do, AMD is pretty much the only game worth watching. AMD's Zen 2 processors are fabricated on a superior 7nm process, allowing for more cores, less power, and higher clock speeds. Intel desperately needs to get 10nm desktop parts on to the market if it wants to compete, and by the time those arrive, maybe 7nm as well. **–JARRED WALTON**

VERDICT 9

AMD Threadripper 3970X

+ BACK TO THE FUTURE Massive multithreaded performance; 7nm technology; innovative chiplet design.

– 1.21 GIGAWATTS Needs a beefy cooler; not backward compatible; games can become overwhelmed.

$1,999, www.amd.com

BENCHMARKS

	AMD Threadripper 3970X	Intel Core i9-10980XE	AMD Ryzen 9 3950X
Blender 2.80 Beta BMW (pps)	**10,651**	5,912	5,719
Cinebench R15 Single/Multi (Index)	210/**7,573**	204/3,799	**213**/3,992
POV-Ray 3.7.1 Single/Multi (pps)	521/**14,754**	**571**/9,379	539/8,334
PCMark 10 (Index)	7,278	7,344	**7,963**
Metro Exodus (fps)	71	87	**90**
Tom Clancy's The Division 2 (fps)	149	**151**	148
Total War: Warhammer II (fps)	72	82	**90**

Best scores are in bold. Our test bench consists of an Asus ROG Zenith II Extreme (TRX40) motherboard, 32GB (4x 8GB) of G.Skill TridentZ RGB DDR4-3200, an Nivida GeForce RTX 2080 Ti, and a Gigabyte Aorus NVMe Gen 4 1TB SSD. All games are tested at their highest graphical profile, at 1080p.

SPECIFICATIONS

Base/Turbo Clock	3.7GHz/4.5GHz
Core/Threads	32/64
Lithography	TSMC 7nm FinFET
Cache	128MB L3
Memory Support	DDR-3200
Memory Channels	4
Max PCIe Lanes	72
Graphics	None
TDP	280W

iBuyPower Intel Z390

A well-priced, quality, good-looking build

IBUYPOWER IS ONE of the more affordable PC builders out there. Obviously, the price of your build will vary depending on what components you put in it, and whether you add any extras—such as an extended warranty or a new monitor—to your purchase. When it comes to the usual up-charge of paying someone else to build your PC, iBuyPower doesn't work out much more than a DIY home build, but this pre-built Intel Z390 9900KS gaming desktop offers incredible value: For $2,300, you're getting a well-designed, high-end build in a small, beautifully unique case. If you've built your own rigs in the past and don't have the time to spare for your next one, this pre-built is a good alternative.

The Slate MR case design stands out from the crowd, especially as iBuyPower cases aren't usually the most glamorous. Oddly, the tempered glass side panel is screwed into the chassis with just two thumbscrews at the back, so the front-facing side of it pops out slightly, but that's the only minor niggle. The front of this case functions like a two-way mirror. You can see your reflection when the PC is off, but as soon as you boot it up, three fans light up from behind like car headlights through the fog. The front is divided into three asymmetrical triangles, which allows for some additional cool air intake next to the right-side vent. Hot air escapes efficiently out the back with a single fan, and through the magnetic dust filter on top.

This PC stays cool even when pushed to the max—impressive, given it's built around an Intel Core i9-9900KS, an eight-core 5.0GHz behemoth of a processor, paired with an RTX 2080 Super. But we wish the default storage was a little more impressive. For about $70 extra, you can get Intel's 760p, which is a better option, as it has average read speeds of 3,040MB/s compared to the 660p's 1,901MB/s that you'll find in here as standard.

Adata is a good choice if you're looking to save the most money on a 16GB RAM kit. However, the timings for the RAM in this desktop are 16-18-18—not bad, but not great. There are RAM kits with better timings out there for a minor increase in price. But better storage and memory won't massively improve performance, so this build comes down to getting the best possible components while saving the most money, which isn't a bad strategy.

For gaming performance, the processor and graphics card are what matter most, and this rig churns out excellent numbers. *Total War: Warhammer II* showed the processor's power at 1080p and 1440p, with an average frame rate between 85 and 120. *The Division 2* averaged 116fps on 1080p and 80fps on 1440p. *Metro Exodus's* performance takes a bit of a hit at those resolutions, with only 80fps on 1080p and 63fps on 1440p; 60 isn't the lowest bar for frame rate, but it's still a gold standard.

4K performance is where things get dicey for this GPU, which is also not unexpected: *Total War: Warhammer II* floated between 48 and 57fps; *The Division 2* averaged 44fps; and *Metro Exodus* averaged 40fps. But, some good news: Ray-tracing performance (set to high on 1440p) on *Metro Exodus* averaged 60fps. Playing at 1080p or 1440p is super-responsive and smooth, and arguably a better choice than 4K for now. Having a good monitor helps, but regardless of your display, this configuration will run games reliably and smoothly.

iBuyPower is a little less enticing on the customer service side compared to other builders. It does build your PC professionally and include all the extra cables in the box, but it's missing that boutique touch, such as neatly wrapped swag or "personal" messaging from the company's president. If you're someone who doesn't need to feel special with those things, iBuyPower is a good no-frills option. **–JOANNA NELIUS**

VERDICT 9

iBuyPower Intel Z390

+ SHINY Great case design; strong airflow; compact chassis.

– FILMY Could use better memory and storage; no Wi-Fi on the motherboard.

$2,300, www.ibuypower.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	2,164 (-1%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	1,901 (-39%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	1,789 (-16%)
3DMark: Fire Strike Ultra (Index)	6,988	6,728 (-4%)
Total War: Warhammer II (fps)	42	54 (29%)
Tom Clancy's The Division 2 (fps)	38	44 (16%)
Metro Exodus (fps)	37	40 (8%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point consists of an Intel Core i9-7900X, 32GB of G. Skill Ripjaws V @ 3000, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro M.2 PCIe SSD. All tests were performed at 4K at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i9-9900KS
Graphics	MSI RTX 2080 Super Ventus OC 8GB
RAM	16GB Adata XPG DDR4-3200
Motherboard	Z390 Gigabyte Aorus Elite
Storage	1TB Intel 660p M.2
Cooling Solution	Corsair H100i Pro 240mm
PSU	Be Quiet! 850W 80 Plus Gold
Case	BuyPower Slate MR
Warranty	Three-year standard

We're fans of the colorful fans.

The numerous heat pipes and fans are visible through a large grille beneath.

MSI GT76 Titan DT 9SG

Stand by for Titanfall

DESKTOP REPLACEMENT laptops seem to be becoming more and more popular. That's bad news for external GPU lovers, but it's good news for everyone else. These laptops are big, powerful, and expensive, often gaming-oriented for maximum performance. The slimmer, slightly less powerful Max-Q variations of Nvidia's GeForce graphics cards aren't needed here; larger chassis and better cooling solutions mean that full-size desktop GPUs are viable in these machines.

This laptop, from MSI's GT76 Titan series, is one such machine. The Titan DT 9SG has a GeForce RTX 2080, an Intel Core i9-9900K, and 64GB of DDR4-2666 memory. It's a monster, with all of those components plugged into a Z390 motherboard. That setup is actually one of the more conservative models of the Titan range, with the most expensive spin packing 10TB of storage in total and a ridiculous 128GB of RAM. That version costs almost $7,000—our review model costs a little under $4,000 .

It's still expensive, but it's not unreasonable for what you get. The Titan has a 4K display and a SteelSeries-designed keyboard, with fully addressable RGB lighting. Breaking down the components, we reckon we could build a desktop with near-identical specs for less than $3,000. Of course, you pay a premium for a high-end laptop, and MSI promises that its gaming laptops are top-of-the-line in terms of design and manufacturing.

Let's put that to the test. The Titan DT 9SG is a heavy, somewhat unwieldy piece of hardware, but that's no different to any other "musclebook" laptop. Upon booting it up, we're struck by a few key observations. The display isn't a true IPS panel, but MSI refers to it as "IPS-level," and it is a quality 240Hz display, providing good clear colors. That SteelSeries keyboard is nice, with a decent amount of travel on the keys. The trackpad is just fine. It's fine. The chassis aesthetics are a matter of personal taste, with some minor rainbow RGB lighting around the edges of the base, but it's mostly plastic, and doesn't feel quite as sturdy as we would like.

Of course, performance is the real tell-all here. This is a theoretically powerful system, and it mostly delivers on that promise of gaming performance. While the screen is 4K, trying to run most games at 4K ultra settings isn't viable, particularly with recent titles. That's not to say they're completely unplayable, but you won't be getting 60fps. Drop the resolution to 1440p or 1080p, though, and you can enjoy maximum graphical settings at a crisp frame rate in the majority of games.

Somewhat surprisingly, ray tracing is actually a viable possibility here; using it in *Metro Exodus* at 1080p ultra settings saw the frame rate stay reliably above 60fps, and even going to 4K and dropping a few graphical settings resulted in a playable state.

The main problem with this laptop is temperature management. Four fans and eleven heat pipes should mean that the Titan has cooling handled, yet it gets extremely hot during gaming sessions. The right-hand air vent on the side of the chassis pumps out hot air, and the underside gets very warm after even just a few minutes of use.

Those four fans? They get loud, too. There's a boost button above the keyboard that punches all those fans into overdrive, sounding slightly like an incoming quadcopter drone, but it doesn't make much difference to frame rates in practice. Even during normal use, the Titan is a noisy machine. Mercifully, the Dynaudio-brand speakers are louder and bassier, providing good sound quality for both gaming and videos.

The GT76 Titan DT 9SG is OK. It's not incredible, but the performance is good enough. It's a bit expensive, but not ludicrously overpriced. We still can't decide if it looks good, to be perfectly honest. Stuff like Wi-Fi 6 is nice, but there aren't any super-exciting hardware features that we can't get elsewhere. In MSI's defense, though, if you're looking for a desktop replacement that you want to use for gaming, you could do a lot worse than the Titan. **–CHRISTIAN GUYTON**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	1,966 (91%)
CrystalDisk QD32 Sequential Read (MB/s)	3,374	3,240 (-4%)
CrystalDisk QD32 Sequential Write (MB/s)	2,530	2,889 (14%)
3DMark: Fire Strike (Index)	13,610	21,497 (58%)
Rise of the Tomb Raider (fps)	92	138 (50%)
Total War: Warhammer II (fps)	62	102 (65%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	69 (41%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Best scores are in bold. Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

VERDICT 7

MSI GT76 Titan DT 9SG

RISE OF THE TITANS Excellent keyboard; amazing at 1080p; handles ray tracing well.

SINKING THE TITANIC Fans are noisy; runs very hot; not great for 4K.

$3,996, http://msi.com

SPECIFICATIONS

CPU	Intel Core i9-9900K
Graphics	Nvidia GeForce RTX 2080 8GB
RAM	64GB DDR4-2666
Screen	17.3-inch 4K IPS-Level (1080p @ 240Hz)
Storage	1TB M.2 PCIe 3.0 NVMe SSD, 1TB HDD
Ports	1x HDMI, 4x USB 3.2 Gen 2 Type-A, 1x USB 3.2 Gen 2 Type-C, 1x Thunderbolt 3, 1x Micro SD, 1x Mini DisplayPort, RJ-45, audio-out, microphone-in
Connectivity	Killer Wi-Fi 6 AX1650, Bluetooth 5.0
Weight	9.3lb
Size	15.6 x 13.0 x 1.7 inches

Content creators won't necessarily benefit from the G-Sync and 144Hz refresh.

Acer ConceptD CP7

A pro display with gaming features. Sorry, what?

THERE ARE GAMING MONITORS. There are pro monitors. But pity the monitor maker that tries to combine both remits in a single screen, right? You'd think so, given the hugely diverging requirements for each market. After all, the pro market is all about accuracy, while gamers want speed, speed, and more speed.

Acer's ConceptD CP7 panel is pitched as a pro panel for content creators, and a high-end model at that, with a price north of $2,000. That's a top-end sticker for a 27-inch screen, even one that combines 4K with a quality IPS panel. What you get for that money, from a pro perspective, begins with factory calibration with a claimed Delta E below one, which is impressive, plus Pantone Validation.

Acer adds 99 percent coverage of the Adobe RGB color space and 93 percent of DCI-P3. These are decent numbers, but at this price point, you'd be justified in expecting fully 100 percent of Adobe RGB and in the high 90s for DCI-P3.

Next up, and the point at which the CP7's content creator shtick begins to come unstuck, involves VESA DisplayHDR 1000 certification. Now, in some ways this is a very good thing. It means the CP7 is capable of a peak brightness of 1,000 nits and packs a backlight with local dimming capabilities. But it's also somewhat tangential to the content creator remit.

Support for processing an HDR signal would be welcome, but it's expensive to achieve DisplayHDR 1000 certification, and it's questionable how valuable it is for content creation. The same but more so goes for the CP7's 144Hz maximum refresh and Nvidia G-Sync Ultimate. These are very much gaming features and both bump up the price. G-Sync Ultimate is particularly expensive and we can't see the value of it for a pro display.

We'd rather see the money spent on improving the color accuracy even further and increasing the number of color space presets available in the OSD. Indeed, as you navigate around the OSD, you'll find several features and options that seem rather dubious for a pro display, including pixel overdrive settings and a crosshair overlay for first-person shooters.

In fact, the overall impression is that the CP7 is a makeover of Acer's 27-inch 4K gaming displays, such as the Predator X27, with added calibration and a more sober suit. That isn't necessarily a bad thing, but it does imply money going in slightly the wrong places given the remit.

It's notable, for instance, that the CP7 lacks USB Type-C. This is likely a hangover from its gaming monitor origins, where USB C isn't a priority, but in a content creation context, where many users will drive the display from a modern laptop PC, the single-cable simplicity of USB C is very desirable. That the stand only offers tilt and height adjustment is also a pity.

As for how it performs, it's one heck of a punchy monitor, even in SDR mode. Of course, the 4K resolution and modest 27-inch proportions make for a nice, tight pixel pitch, very sharp fonts, and loads of detail. HDR content zings. We also noted perfect gradient rendering and no evidence of compression in test images.

Predictably, given the IPS panel tech and premium position, viewing angles are pretty much impeccable and the color balance is natural and vivid. The 144Hz refresh is also nice to have. It's really a gaming feature, but it makes the Windows interface feel tangibly more responsive.

This is a very nice display. The problem is one of priorities. The CP7 is packed with fantastic tech, but the result is more of a luxury all-arounder than a monitor tuned for content creators. **-JEREMY LAIRD**

VERDICT **8**

Acer ConceptD CP7 CP7271KP

CREATOR Stunning feature set; nice styling; great all-around performance.

CREATIONIST Painfully pricey; gamut coverage could be better.

$2,199, www.acer.com

SPECIFICATIONS

Panel Size	27-inch
Panel Type	IPS
Resolution	3,840x2,160
Pixel Pitch	163 ppi
Brightness	600cd/m^2
Contrast	1,000:1
Pixel Response	4ms
Refresh Rate	144Hz
VESA	100 x 100mm
Inputs	DisplayPort, HDMI

HP Spectre x360 13

Guess who's back!

THE FLIP-FLOPPY 360-degree version of the HP Spectre is back, with a new trick up its sleeve: a 10th-generation (Ice Lake) Intel Core processor, specifically the Intel Core i7-1065G7. Equipped with shiny new Iris Plus integrated graphics and an improved battery, this is a seriously sleek piece of hardware.

The original Spectre x360 was a fundamentally good convertible laptop (we gave it "8" when we reviewed it last year). There's a lot that hasn't changed here; we might criticize other products for a lack of innovation, but the x360's chassis is so well designed that we can't be mad. Our review unit has a lovely dark finish, and as we flex it between laptop and tablet orientations, we're reminded of how sturdy this two-in-one is.

The angular corners that contain the power button and one of the USB-C ports still look great, and the softly backlit keyboard sits comfortably in the perforated aluminum chassis. It's a timeless design that captures all the aesthetics deemed necessary for a stylish piece of ultralight hardware. The screen bezel remains tiny, a slender strip of black surrounding the 4K display.

Speaking of the display, it's the best it's ever looked in this model, a 13.3-inch AMOLED panel covered in anti-reflection Gorilla Glass that actually works pretty well when using this Spectre in a well-lit environment. The screen is bright and has solid color density, with satisfyingly deep blacks. It's a touchscreen, too, of course, and the Spectre x360 comes boxed with an HP Tilt Pen, if you're the artistic type.

So, the external hardware is still the "8" we gave it last time. This model also carries forward a few minor irritations of the older model. The main fan is still quite noisy when the CPU is running at load, producing a tinny whine, although it's not incredibly distracting (it only became significantly noisier during our 3DMark Fire Strike benchmark). It's also a smidge heavier than many of the ultralight convertibles we've handled.

The new features blow the older models out of the water, though, eliminating many issues with the eighth-gen Intel model we reviewed previously. The NVMe SSD is speedy in both reads and writes, and double the memory (up to 16GB from 8GB) makes for a more capable creative machine. Plenty of existing features make a welcome return, too, most notably the security-oriented additions; a physical webcam kill switch, mic mute button, and fingerprint scanners are all good elements. The custom-tuned Bang & Olufsen audio is back, too, providing some great sound quality for such a small device.

Of course, the main draw here is those integrated graphics: Intel's Iris Plus tech, currently only found on its 10th-gen mobile CPUs. Iris Plus is a huge step up from the previous Intel UHD Graphics 620, providing almost double the performance in some tests. Gaming performance is significantly better, but this isn't really a system for gaming; you'll need to drop the settings by a lot and keep the resolution at 1080p or lower to ensure a stable experience. Still, it's far more than previous APUs could manage, so the new processor is definitely a win.

Despite Intel's eagerness to promote its new laptops as part of Project Athena, the battery on this machine is actually less powerful. Moving ever so slightly from a 61Whr lithium-ion battery to a 60Whr unit, along with a more powerful processor and more memory, reduces the battery life, although it's still perfectly respectable. We'll take a small hit to battery life any day for the overarching improvements that cover every area of this system. And it is indeed improved; we still remember how much we liked the eighth-gen Spectre x360, but this feels like the perfected version. It's hard not to love this hybrid laptop-tablet; it feels great to use in tablet mode, as well as the usual laptop format, looks fantastic, and retains the all the most useful features of the original model. **–CHRISTIAN GUYTON**

VERDICT

9

HP Spectre x360 13 10th-Gen

+ CASINO ROYALE Great external design; awesome performance; security features are still good.

– DIE ANOTHER DAY Battery life takes a hit; fan is still a bit loud.

$1,500, http://hp.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	561	686 (22%)
CrystalDisk QD32 Sequential Read (MB/s)	3,100	3,298 (6%)
CrystalDisk QD32 Sequential Write (MB/s)	557	2,399 (331%)
3DMark: Fire Strike (Index)	1,062	2,031 (91%)
Rise of the Tomb Raider (fps)	5	8 (60%)
PCMark 8 (Index)	2,543	3,244 (28%)
Battery Life: Movie Playback (Mins)	840	720 (-14%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our notebook zero-point is the HP Spectre X360, with an Intel Core i7-8565U, integrated Intel UHD Graphics 620, and 8GB of DDR4-2400. *Rise of the Tomb Raider* is tested at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-1065G7
Graphics	Intel Iris Plus
RAM	16GB LPDDR4-3200
Screen	13.3-inch 4K AMOLED
Storage	512GB PCIe NVMe x4 SSD
Keyboard	Island-style backlit
Battery	Four-cell 60Wh
PSU	65W AC adapter
Weight	2.9lb
OS	Windows 10 Home 64-bit

The system inside this familiar chassis has been juiced up significantly.

Google Stadia

Convenience with a catch-22

STADIA IS LIKE other cloud gaming platforms: great for single-player games, terrible for multiplayer if your Internet isn't great. It's a cool innovation, free from the hardware that a PC needs, but it's only as good as an Internet package. When things go wrong, figuring out why can take even more technical savvy than building the best gaming PC. Added to that, Stadia's launch is simply missing many of the features it needs to be a robust gaming platform.

Setting up Stadia is a bit of a process on TV: Connect the Chromecast Ultra to the Google Home app on a smartphone; configure the user's Stadia account; sync a controller; and start playing games. (On PC, just log into the Stadia site in Chrome.) Once you get into a game, there are lots of missing features, such as graphics options—aside from *Shadow of the Tomb Raider*, which confusingly gives you a choice between quality and performance when you're supposed to set the resolution from the Stadia app (which also controls the data usage). Compared to the hardware needed to run PC games at 4K, though, Stadia's launch price of $130 is a bargain, as is the $10 per month Pro subscription. The 4K option is only available with Stadia Pro, but isn't available on PC.

Stadia recommends a minimum connection of 35Mb/s to play games in 4K, but not all its games ran perfectly, even on a higher bandwidth. Running Stadia on two different ISPs (Spectrum and AT&T) in two different locations (Orange County and San Francisco) at the same base max speed (120Mb/s), nearly every game tested performed either slightly under or on par with a local machine at 4K and 1080p, but something just felt "off" visually when playing *Shadow of the Tomb Raider* and *Destiny 2* via Stadia on PC, rather than on a local machine. That "off" feeling was Stadia running with double the input latency on PC compared to native PC gaming.

For anyone with a data cap, Stadia's data usage is as taxing as feared: 2.5 hours of game time at 4K consumed around 40GB of data. Playing Stadia at 4K for 2.5 hours every day for 30 days will use about 1.2TB of data. Those with data caps can forget about daily 4K gaming.

Google claims that games will run flawlessly at 4K at 60fps with an Internet speed of 35Mb/s. There's some truth to that. Some single-player games can perform near-flawlessly at 4K at as low as 25Mb/s, but *Destiny 2* proved unplayable at that low a download speed. On 35Mb/s at 4K, there was massive lag, input latency, pixelation, and frame rate drops. This persisted until the bandwidth was raised to 100Mb/s.

The Stadia controller is solid, with weighty-enough buttons and two sturdy thumbsticks that move smoothly. It looks and feels like a combination of the PS4 and Xbox controllers, with the bumpers spread out like the PS4 version. If you have small hands, you may experience finger fatigue after a while, but the controller is comfortable enough.

Taking screenshots and clips via the controller saves them directly to the Stadia app, but you can only see them on your phone. There isn't even a way to share or download screenshots from your phone, only delete them. The Stadia controller also doesn't work wirelessly with a PC.

With the right combination of fast, reliable Internet service, a good modem and router, and an ISP that doesn't cap your bandwidth, Stadia is a welcome alternative to PCs and consoles. But right now, Stadia is missing a bunch of extras that we love about gaming, and there's still a huge performance divide between single-player and multiplayer games. Google's proven Stadia's tech really can work—but it's also proven that without its many missing features, it's rarely going to be the best way to play any of the games on its service. –JOANNA NELIUS

VERDICT **6**

Google Stadia

CIRRUS Can fit in a small bag; decent game lineup.

NIMBUS Relies heavily on a fast, stable Internet connection; can't purchase games from Chromecast interface; no 4K on PC.

$129 (Premiere Edition), www.stadia.com

SPECIFICATIONS

Wi-Fi	Dual-band (2.4GHz/5GHz) IEEE 802.11a/b/g/n/ac
Bluetooth	Bluetooth Low Energy 4.2
Headset Jack	3.5mm for headset with or without a microphone
USB	USB-C port for charging, wired gameplay
Network Requirement	10Mb/s minimum, 35Mb/s for 4K
Battery	Rechargeable Li-ion
Dimensions	6.4 x 4.1 x 2.6 inches
Weight	9.45oz

Corsair Ironclaw RGB Wireless Gaming Mouse

Comfortable palm-grip king

MICE ARE FICKLE THINGS. Each style of grip and gameplay requires a different consideration. A palm-gripper inevitably holds a mouse far more obtusely than a claw-gripper, and Corsair set out to design its Ironclaw RGB Wireless with one audience in mind: the right-handed palm-gripper. And you can tell.

It's the shape that really sets it apart. It's tall in the middle, sloping off to the rear dramatically, with a molded side-grip to the left for your thumb to rest in, and a pleasing groove cut out on the right for your pinkie and index finger. Each side grip is comprised of rubber silicone, etched in a diamond pattern. What's most impressive here is that the pattern has a varying texture height. At the bottom-left of the thumb grip, the grooves are deep, improving friction and helping to keep your thumb in place, similar to the sipes on a winter tire. Move your eyes along to the upper-rear of that grip, and you'll notice that the etching becomes smoother and less pronounced, reducing potential irritation around the joint in your thumb as it moves up and down to hit those three side buttons. Outside of the grips, the top is covered in a soft-touch finish to reduce greasy fingerprints and aid comfort, there's a smidge of glossy plastic lining the bottom-rear of the mouse, and an aluminum brace at the very front, which we can only assume is there for styling.

The button layout is also conducive to that palm-grip style. On top of the left-click, right-click, and mouse wheel buttons, you get seven additional programmable switches. There are two behind the mouse wheel to control on-board profiles, two to the left of the left-click, which adjust between CPI settings (noted by three LED lights located below them), and three above that thumb grip we mentioned earlier. Admittedly, having those two CPI switches to the left may sound a little odd, as we're used to them being located behind the mouse wheel, but it actually feels far more logical. It takes a while to train your brain, but it's far quicker, and provides more stability to shift CPIs on the fly when using them—something that is incredibly useful for FPS games, when you need to nail that quick snipe. The three buttons located above the left grip are also easy to reach with your thumb, although if you do go for the upper-middle button, you will lose a slight amount of accuracy and grip on the mouse itself, so it's probably best if you don't bind it to anything too mission-critical.

The Ironclaw's true potential, however, comes with its profile software. Dive into Corsair's iCUE desktop suite and you can configure individual profiles for each game you play, complete with different CPI settings, macros, and lighting setups, so you know which is which immediately. Upload them to the mouse and you can then quickly switch between them with the profile buttons situated behind the scroll wheel on whatever system you've got the Ironclaw plugged into.

And then there's the sensor—a Pixart PMW3391 optical variant, designed in conjunction with Logitech. The 3391 continues to track accurately up to 18,000 cpi, 50Gs of acceleration, and at 450 inches per second. Which is, let's face it, ridiculous. However, those improvements do show at the lower more commonly used CPIs, and it tracks incredibly well because of it.

Couple all of that with a hefty number of connectivity options, including USB, Bluetooth, and wireless 2.4GHz (via a dongle), and a 50-hour battery life, and the Ironclaw is nothing but impressive. Corsair has designed a fantastically sharp palm-grip mouse, complete with an incredible array of tech, both at the hardware and software level. Despite its outlandish looks, it's perhaps the most comfortable palm-grip mouse we've seen since the Mionix Castor. Combine that with the fact it's regularly available for less than $75, and it's one of the cheapest, high-performing wireless mice available today. **–ZAK STOREY**

VERDICT 9

Corsair Ironclaw RGB Wireless Gaming Mouse

FIGHTING PEACOCK Incredible palm-grip comfort; strong sensor performance; intuitive layout; good price.

CHICKEN Somewhat heavy; not as proficient for claw/fingertip grips.

$75, www.corsair.com

SPECIFICATIONS

Sensor Type	Optical
Sensitivity	100–18,000 cpi (1 cpi increments)
Sensor Model	Pixart PMW3391
Polling Rate	125–1,000Hz
Programmable Buttons	5
LEDs	Four zones, 16.8 million colors
Cable Length	6 feet
Weight	4.6oz

SteelSeries Arctis 7 2019 Edition

If an awesome headset ain't broke, don't fix it—just tweak it a bit

SINCE IT ARRIVED just a couple of years ago, the Arctis range has earned SteelSeries so many awards you'd half-expect to hear it namechecked at the Oscars. An innovative elasticated headband design that SteelSeries calls the ski-goggle, plus powerful drivers that deliver a pleasantly flat response, have contributed to its status as PC gaming audio's Meryl Streep. And with this updated version of the Arctis 7, the sweet spot in terms of value in the range, SteelSeries looks to cement its status as the go-to headset, wireless or otherwise.

Let's start with the changes to the existing Arctis 7, because they're not exactly glaring. Visually, there's almost no difference at all. You'd have to be pretty au fait with the 2017 model to notice that the earcups are now marginally more padded, and the headband has changed just slightly, falling in line with those featured on the top-of-the-range Arctis Pro models. Subtle though they are, these tweaks do make a difference to overall comfort. And as has been made abundantly clear about the Arctis range, comfort wasn't exactly lacking before.

While most headsets get around the problem of putting their weight across the top of your head by using padding beneath their aluminum headbands, this Arctis 7, and its stablemates the Arctis 3, 5, and Pro, use an elasticated band to keep that aluminum part away from your head altogether. It uses the tension of the ski-goggle band to keep the heavier materials suspended over your head, thus eliminating a heavy contact point, and increasing your comfort. That design really pays off in reality, and although the ski-goggle bands do slacken and lose elasticity after months of heavy use, you can buy a replacement band from SteelSeries for $15.

The same goes for those earcup pads, which will theoretically last even longer in this 2019 edition, by virtue of featuring more memory foam padding. But when the day arrives that they start to lose their form, swapping them out for another set costs just $12. And there's a choice of leatherette or microfiber cloth finish, too, which has a surprisingly profound effect on the sound.

We can't ignore a segue like that—on to the audio properties. What we have always enjoyed about the distinctive Arctis "tone" is how flat an EQ response it features. While most gaming headsets feature a "v-shaped" EQ, which boosts the lows, scoops the mids, and pushes the highs, so that bombastic game audio sounds even more bombastic, these Arctis 7s sound more like enthusiast headphones that just happen to feature a mic and work great for gaming. The bass doesn't disturb clarity higher up the EQ, and it's not tuned so specifically for the soundscapes of *Battlefield* et al that you can't enjoy a bit of music or the odd podcast in your downtime.

If there was a chink in the armor previously, it was in overall volume. Only otolaryngologists would have approved of the 2017 Arctis 7's surprisingly low maximum volume. It might not have proved troublesome for everyday use, but could be an issue in louder environments—so it's great to see this 2019 edition is noticeably louder. Roughly 50 percent louder, if our Windows volume percentage is anything to go by.

Many users have reported a notable upgrade in clarity and bass response when using the latest version of SteelSeries Engine, too. This is available across all Arctis headsets, from the 5 onward, so it's not specific to this 2019 edition of the 7, but SteelSeries continues to invest in the Arctis's performance long after it's become an established presence in "best gaming headset" round-ups Internet-wide.

So, while owners of the older Arctis 7 models don't have any cause for sleepless nights, anyone who hasn't tried one out yet has even more reason to do so now with the 2019 edition. Slightly comfier, slightly louder, and as great to listen to as ever. **–PHIL IWANIUK**

VERDICT 9 KICK ASS!

SteelSeries Arctis 7 2019 Edition

BLUE STEEL Flat, articulate sound; comfier than ever; louder than the original.

MAGNUM Headband does slacken with use.

$129, www.steelseries.com

SPECIFICATIONS

Driver Type	40mm neodymium
Frequency Response	20Hz–20KHz
Design Style	Closed back
Microphone Type	Retractable electret condenser
Weight	0.8lb
Connectivity	Wireless via USB transmitter
Cord Length	N/A

Cooler Master MasterCase H100

Keeping it compact

ITX CASES ARE A RARE BREED, and good ITX cases are even rarer. The last compact case this reviewer handled demanded a blood sacrifice during the build process, but we're pleased to report that no fingertip incisions occurred this time around: No tech journalists were harmed in the making of this review.

The MasterCase H100 isn't Cooler Master's first ITX case, but we feel like it might be the best yet. Previous ITX cases were confined to Cooler Master's Elite line, and were significantly uglier. The Elite cases were pretty simple, blocky affairs, reminiscent of old VHS players, while the MasterCase H100 has a far more modern design.

The H100 uses a combination of plastic and metal, with steel side panels and internal frame, covered at the front and top by a solid plastic cover and front I/O. The mesh covering the front fan and top cover are steel mesh—and let's talk about that fan. It's a giant 200mm unit, made of translucent plastic that illuminates to excellent visual effect. Thanks to its size, it can run quiet while still pushing a lot of air, and there's even room behind it for a cooling radiator to be installed (although this limits the amount of GPU clearance inside the case).

Building a straightforward ITX system in this case took less than an hour, thanks to some smart internal design. The mount for the PSU extends out from the back of the case by about an inch to allow for more space inside, and can be removed completely and more easily attached to the PSU. There's room for a GPU here, too, although only single-fan and smaller twin-fan models are likely to fit. There are multiple SSD mounts in the base and side of the case, and some of those can be removed to free up a bit more room if you're not using them. Surprisingly, there's even room for a 3.5-inch HDD to be fitted in here. Yes, it's a bit cramped to work with, but that's the case with any Mini-ITX chassis.

Cable management is where things start to get a bit ropey. There aren't any windows, just the dark metal mesh on the front and top, so messy cables won't be on display. But that could be the least of your worries; that large case fan is mostly exposed at the rear, and any fans on your CPU cooler or GPU need to be avoided by any cables within the case. A modular power supply is effectively a must-have; loose cables from a non-modular PSU will get in the way.

Speaking of CPU coolers, there's little space for them here. The H100 actually does take a standard ATX power supply (a nice addition, as smaller PSUs tend to be more expensive and less efficient), but that leaves less than three and a half inches of space beneath the power block for the CPU cooler. Liquid cooling is just about possible, thanks to the radiator space at the front of the case, but there's little room for anything beyond small stock coolers. We used an AMD Wraith Stealth cooler for our review build in this case, which worked perfectly well.

In all honesty, though, these are all minor concerns. Like tiny imperfections in the surface of a CPU's heat spreader, they don't impede the role of this case in the slightest—and they're failings that just about any compact case is sure to share. The H100 is a genuinely good product, ideal for a living room PC or portable gaming rig (thanks to the handy-dandy carrying handle on top). There's certainly potential to build a reasonably powerful PC, and with a bit of effort put into neatly bundling your cables, it should look good, too. The case fan is bright and makes an excellent sight through the steel mesh, and the sturdy construction means we have few concerns about the case's structural integrity. We like it a lot, and if you're looking for a small case, we think you will, too. **–CHRISTIAN GUYTON**

VERDICT **9**

Cooler Master MasterCase H1000

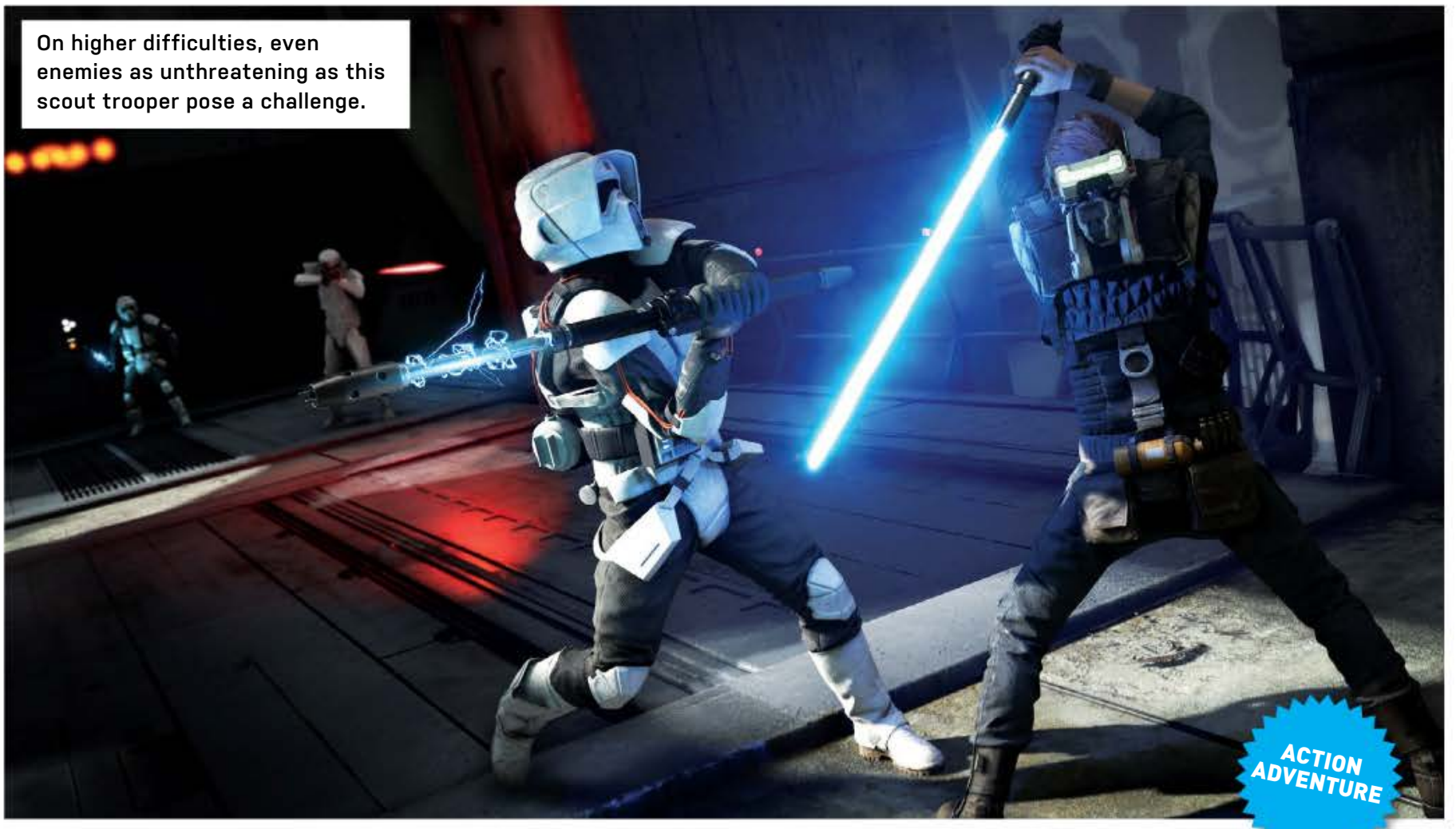
TEENY Excellent compact design; good fan; portable; room for a GPU.

WEENIE Requires a modular PSU; minimal CPU cooler clearance; cable management is tough.

$70, http://coolermaster.com

SPECIFICATIONS

Form Factor	Mini-ITX
Motherboard Support	ITX
Colors Available	Black, iron gray
Window Available	No
3.5-Inch Support	1
2.5-Inch Support	4
Radiator Support	200mm front
Fan Support	1x 200mm front
Dimensions	12.2 x 8.5 x 11.9 inches
Graphics Card Clearance	6.5 inches



On higher difficulties, even enemies as unthreatening as this scout trooper pose a challenge.

Star Wars Jedi: Fallen Order

Attacking the clones

THERE IS NO framework in entertainment that you can't stretch *Star Wars* over and make into a success. Just look at *Episode 1 Racer* or the Western tropes of *The Mandalorian. Fallen Order* chooses not to retread the *Jedi Knight* games, but goes after two more recent console stalwarts: *Uncharted* and *Dark Souls.*

The latter of those has a reputation for difficulty, but how hard can chopping down stormtroopers be when you're armed with a lightsaber from the start? The answer is "very." *Fallen Order* balances this with a Story difficulty level that tones things down considerably for those who want to be in with a chance of seeing the credits. The *Uncharted* influence—all wall runs and leaps of which Luke Skywalker would be proud—fits so beautifully with the Jedi mythos that tougher stormtroopers deserve to be an optional extra.

What the game inherits from *Star Wars* is worth the price of admission for fans. Hand-crafted alien worlds, new lore, and old references. Force powers to send blaster bolts back whence they came and slow the blades of massive fans, so you can pass through without getting minced. It's all being a Jedi on the run should be.

Shame you're such a dullard. Hiding out at a spaceship scrapyard in the gap between *Revenge of the Sith's* Order 66 and *A New Hope,* padawan Cal Kestis is surly, with floppy hair, and in any other media would have a flashing sign over his head saying "Will Fall to Dark Side." That's been ruled out here—it's not *Knights of the Old Republic*—but Cal is just a little too close to the teenage angst of prequel-era Anakin Skywalker for our tastes.

Luckily, the universe he exists in is a rich one, and depending on how you like your combat difficulty, there's plenty to see and do. Cal has a rare Force ability that enables him to see "Force echoes" of events in the past. Through this ability, he can pick up on plot points not otherwise directly shown to the player—a useful skill in a videogame protagonist.

Cal spends a lot of time repairing his connection to the Force, "remembering" skills he once had, and using them to fight off ever-tougher opposition. He powers up at meditation spots, putting points into skills as if this were a Ubisoft game. These spots also have the unfortunate side effect of causing all defeated enemies to respawn when used, so you are often forced to choose between new skills or a relatively safe back-track through an area you've already cleared. Most of the time, you'll want to choose the new skill, because it's necessary to access an area of the level previously denied to you.

He aids the resistance on Kashyyyk, undertakes Jedi trials, cuts off the hands of antagonists, builds and modifies lightsabers, takes up with a crew of space adventurers, and attempts to discover the secrets behind a long-vanished race. But what Cal never does is be likeable, his sulky demeanor begging for a dash of John Williams' "Imperial March."

This is a shame, because with a more charismatic lead, the intelligent mix of influences could have created something truly great. As it is, the framework beneath the *Star Wars* wrapping is enjoyable enough even if you don't care about the lunk with the lightsaber. **–IAN EVENDEN**

VERDICT 8

Star Wars Jedi: Fallen Order

WOOKIEE *Star Wars* improves everything; good mash-up of game frameworks.

ROOKIE Bit too long; protagonist is largely unremarkable.

RECOMMENDED SPECS Ryzen 7 1700/ i7-6700K; 16GB RAM; Vega 56, or Nvidia GTX 1070/GTX 1660 Ti.

$60, www.ea.com, ESRB: T

© RESPAWN ENTERTAINMENT

Rail heists are some of the most exciting set pieces on offer.

The beard-rendering tech shines among these rugged faces.

Chase down witnesses to your crimes, and they won't rat you out.

Towns, complete with saloon, are exactly what you'd expect.

ACTION ADVENTURE

Red Dead Redemption 2

At last, the *GTA* dev's magnum opus bursts on to PC

ROCKSTAR'S PAEAN to the final days of the Old West has been a long time coming to PC, but it's been worth the wait. The launch was a bit bungled, but it's no longer a problem. We fixed repeated quits to desktop by starting the game in Safe Mode, and re-enabling graphics options in a tiny 720p window. Thanks to patches, the game no longer quits, but we still love to play with the video settings, as the game rewards an understanding of how certain effects will affect your frame rate.

Given enough processing power, the game looks incredible. The opening snowfields of the Grizzlies mountains are harder on the GPU than the green, open Heartlands that follow, probably because of all the particle effects being thrown around. Late-game city Saint Denis will push down your frame rate again, its bustling streets alive with trouble.

The console version hovers around the low to medium settings, so you can start to see the scale of the thing. With mid-range equipment—say 1080/2060 level—you'll get a nice 1080p picture. It helps that the whole thing has been designed with a cinematographer's eye for framing and an attention to detail that just won't quit. Every frame is a screenshot, photo mode is always available, and that makes choosing real screenshots to accompany a review like this more difficult than usual.

We persevere, though, because we care. And because playing a game like this encourages it. For all that it's an Old West sandbox, in which you can play as a bounty hunter, fur trapper, or black-hat gunslinger, it's also a story about the end of a way of life, and it gets mighty whimsical amongst all the killin'. Arthur Morgan and the rest of Dutch van der Linde's gang start on the run after a job gone awry, eventually moving from the cold mountains to somewhere more agreeable. Trouble follows, naturally, but there's often a non-violent way out of the situation if you can manage to pull it off.

One sees us helping a wagon driver held up by bandits. We kill 'em all, sending him into paroxysms of gratitude, but on remounting our horse, accidentally run him over. We lose reputation, and all the way into town, we're harangued by a female NPC about why we didn't stop to help the wagoner, replying that we were just a bad guy. Another time, we've killed a guy who keeps pigs. Shooting one with an arrow, we sling it over our horse, our mind so fixed on the resulting stew that we don't think twice before defending a stagecoach from outlaws. Naturally, we get killed, and respawn without our pig. Checking back at the farm reveals all the other pigs have vanished too. Dang.

Glitches and annoyances are rare, though. The game is a slow-burner, but delivers action set-pieces greater than any we've seen. Dead-Eye, which slows combat and encourages accurate headshots, enhances this, giving you a huge advantage over groups of criminals.

That Rockstar—a developer that's given us multiple tightly packed cities in which we steal cars to race to the next location—should produce as its best work a game in which you trot through wide-open spaces on a horse you've bonded with over time is a delicious irony you'll have plenty of time to savor. **–IAN EVENDEN**

VERDICT 9 KICK ASS!

Red Dead Redemption 2

GOOD A magnificent rendering of the Old West; spectacular cowboy action.

BAD/UGLY Very hard on gear if you want 4K, ultra, high frame rates.

RECOMMENDED SPECS i7-4770K/Ryzen 5 1500X; 12GB RAM, GTX 1060 6GB/Radeon RX 480 4GB.

$60, www.rockstargames.com, ESRB: M

© ROCKSTAR

LAB NOTES

JARRED WALTON, SENIOR EDITOR

Progress Isn't Just at High End

AMD's RX 5500 XT trims Navi for budget and mid-range market

IT'S EASY TO get caught up in the excitement of extreme performance hardware. I do it all the time, and it can really skew your perspective if you're not careful. I imagine it's like someone who drives a Ferrari or some other exotic sports car taking a cruise in a typical sedan. No matter how good they might get, Honda, Toyota, or any other mainstream vehicle is never going to impress such a connoisseur.

After testing a bunch of high-end graphics cards, AMD's budget offering feels tame. The Radeon RX 5500 XT, with either 4GB or 8GB GDDR6, doesn't look like much. But take a step back from the bleeding edge, and progress is still alive and well, even in budget land.

The Navi 14 GPU in the RX 5500 XT has 1,408 GPU cores, about 30 percent fewer than an RX 570. Even with higher clock speeds, on paper it's 5,196 GFLOPS of compute, compared to 5,095 GFLOPS—both with 224GB/s of bandwidth. That should be a tie, but paper specs rarely tell the whole story. It turns out Navi's architectural improvements do make a big difference.

It varies by game and settings, but the 5500 XT 4GB card sweeps the benchmarks compared to the 570 4GB, with 30 percent higher performance on average. The 5500 XT 8GB card ends up matching the RX 590—still with 1,408 cores going up against the 590's 2,304 cores. Navi looks to be about 35 percent better IPC for the GPU, in other words.

The only concern is pricing. RX 570 has been selling for $130 all year, and the launch price for the 4GB 5500 XT is $169. That's a jump in generational pricing for a budget GPU, but ultimately the new budget cards end up being far more interesting than the outgoing models.

On paper the 5500 XT isn't much of an improvement, but the reality is a different matter.

JOANNA NELIUS

Hardware Staff Writer

A couple of months ago, I said goodbye to the last desktop PC I built. It's not dead; I donated it to a well-deserving young kid who loves *Subnautica, Planet Coaster,* and making animated videos. I wrote about my old AMD FX-6300, GTX 1050 Ti build back in April 2019, and how it was my trusty, sturdy tank that stood with me through thick and thin. Now I've found a good home for it, and I hope it's bringing him as much joy as my dad's hand-me-down PCs brought me—and I encourage everyone who threw down wads of cash on a new rig over the holidays to consider gifting their old PC to someone. Or to donate it to a non-profit that repairs and repurposes them for individuals in need. Not to mention it cuts down on e-waste in landfills.

If you look at the cost of gaming PCs these days, they still cost hundreds—sometimes thousands—of dollars. The technology has advanced, but the prices are the same. According to human-I-T, a Long Beach, California-based non-profit, 82 million Americans lack access to a computer with Internet in their homes, primarily because of cost. At the same time, 150,000 computers are disposed of every day in the US. There's someone out of those 82 million Americans who could use it more than a recycling center or a landfill.

Editors' Picks:
Digital Discoveries

Executive editor, Alan Dexter, and staff writer, Christian Guyton, have been taking control of their virtual lives

HEARTHSTONE

After the release of *MTG Arena*, I haven't spent much time with Blizzard's take on digital card games. *Hearthstone* was fun when it came out, but a series of weak expansions and its inherent limitations meant it was as easy to drop as it was to pick up in the first place.

I have found myself back in the game recently, though, and it's down to the new game mode: Battlegrounds. Currently in Beta, Battlegrounds offers up a refreshing take on *Hearthstone's* normal games, by having you compete against seven other players, building decks from random cards. You pick a character to play with at the start; each with a different hero power—some are better than others, but they all have interesting synergies.

The fights are free of any interaction, with each of your minions picking fights with your opponent's minions at random; only their fight order is predetermined. This adds a small amount of strategy to proceedings, although the random nature of the fights can be frustrating when your superior army is taken down by poor selections. Still, it's the most fun I've had in *Hearthstone* for a long time, and a good reason to revisit it.

Free, www.playhearthstone.com

CONTROL

I've been a fan of Remedy's games for ages, right back to the original *Max Payne*, so I was amped to dive into Remedy's newest sci-fi adventure. I was expecting to enjoy *Control*, but I wasn't expecting it to blow me away like this.

The action is all top-notch stuff, fulfilling that superhero power fantasy while never quite letting us forget that our determined protagonist Jesse is still only human. The game isn't exactly easy, but you've got a shapeshifting gun and some awesome telekinetic powers at your disposal.

The real star, though, is the setting: the Oldest House, a brutalist concrete monolith lurking invisibly in central NYC. The House is alive; shifting and changing its architecture, bending gravity and dimensions, containing within it passages to other locales and even other universes.

As well as being good to explore, the House reacts wonderfully in combat; Jesse yanks chunks of concrete from the ground to form a floating defensive barrier, while telekinetically launching a desk through a cramped office sends stationery and mugs exploding into the air. The whole environment is physics-enabled, and like nothing else I've ever played.

$50, www.remedygames.com

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GEEK TESTED & APPROVED

Braven BRV-Mini Speaker

RUGGED HARDWARE isn't for everybody, but if you like to take your music to the great outdoors, Braven has the speaker for you. The Zagg-owned brand offers a handful of different reinforced speakers, but for our money, the BRV-Mini is the best of the bunch—less than four inches tall, but still capable of pumping out awesome audio.

Honestly, we were shocked by the volume this little cylinder can produce. Music fills rooms, able to hit the high notes as well as deeper bass, thanks to an internal passive radiator. There's a mic for hands-free calls, too.

The battery is impressive; Zagg claims that the speaker can play up to 12 hours of music, and we used it for a full day without having to charge it.

Then there's that sweet rugged design. The BRV-Mini has a solid exterior, with hard rubber padding at either end, and a thick fabric mesh around the speakers. The buttons sit underneath a layer of rubber on top, but still have a satisfying click. The Mini comes with a small lanyard and is fully waterproof. The website told us that it floats, too, so we did what any rational person would do: Fill up the sink and chuck it in. Not only did it float, but it kept blasting out the jams the whole time, so you can definitely bring this bad boy with you to the pool.

There's virtually no setup either; link it via Bluetooth, and you're good to go. Oh, and did we mention that you get all this for only $40? Because you do. **–CG**

$40, www.zagg.com/braven

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> History Lessons
> CPU Specifics
> $500 Build It Challenge

History of PCs

Long-time reader, first-time writer. I loved the article on the history of PCs. Brought back great memories, such as staying after school in 1979 to play games on an Apple IIc, and getting an 8088 XT with a monochrome monitor when I graduated high school in 1989. I was shocked to see all the love for IBM and a slant that it was open architecture. Why no mention of its major misstep with MCA (micro channel architecture)? I actually believe that failure is what led to the rapid adoption of ISA and EISA, and proprietary technology forever went by the wayside in the clone wars.

–Eric Jeffery

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Glad you enjoyed the article. We loved that trip down memory lane, too. There are lots of angles we could have taken with it, and ultimately we thought focusing on IBM was the clearest way of getting across some of what happened. We could probably fill several issues with the evolution of the PC as we know it today, but there's a very good chance we'll revisit some of the more important milestones in the future, so keep watching this space.

Technical Trio

Years ago, I was a computer programmer. If I wrote a program for a specific processor, say a Motorola 6800, all was well. Then, if the next customer had a computer using an Intel 80286, and wanted the same program, I had to completely rewrite the program for the new processor. Today, I can find computers to purchase that all use different types and models of processors (CPUs). Yet they all profess to run Windows 10. How can that be, since there is only one version of Windows 10?

Over the last few years, the magazine has been recommending various monitors. Not once have you mentioned a ViewSonic VP3268-4K. Why? I have used this screen for about a year now and it is a great monitor. I feel you are short-changing your readers by not mentioning it. Confession: I am not much of a gamer, but I was very concerned about resolution and color accuracy.

I notice you almost always put two disks in a system. A smaller one for disk C and a larger one for a data disk. You should be using much larger disks for disk C. Why? When I install new software, 90 percent of the time it installs it on disk C without giving me a choice of where I want it installed. When I purchased my current computer several years ago, it came with a 256GB C drive. I filled that up in no time and had to replace it with a 1TB disk. Remember that software, including games, is being created using humongous sizes and numbers of files. Just a tip.

–jkryder

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: Programming hasn't changed that much—software still needs to be written for the underlying hardware. Compilers have gotten much better when it comes to optimizations, though, and you have to code for CPUs in general, rather than specific chips. There are broader strokes at work when it comes to Windows as well. Windows 10 essentially works on any x86 hardware (the 32-bit and 64-bit versions of Windows 10 are actually separate entities), and Microsoft has been making advancements when it comes to running Windows 10 on ARM-based chips as well. So there are actually several versions of Windows 10, although each supports a wide range of chips.

As for your monitor, I did have a long answer prepared about the number of screens available at any one time, how ViewSonic has over a hundred monitors in production right now, and that we can't possibly look at them all. Then I realized we did actually look at that very screen back in the Spring 2018 issue. Indeed, we came to the same conclusion as you did as well, giving the VP3268-4K a score of nine for its great feature set and quality IPS panel.

Finally, the reason we go for two drives in most non-budget systems is to aid keeping your data and system files

↘ submit your questions to: comments@maximumpc.com

separate. There's a couple of reasons for doing this, some to do with price and performance (having a speedier NVMe system drive makes sense, while your data doesn't need to be accessed so quickly), and this arrangement means that you don't lose everything should one drive fail. We do, of course, assume that you keep proper backups of everything. But yes, you do need a big enough drive to hold Windows and your apps for this to work.

$500 Build It Challenge

After seeing the article in the December issue, I ordered the parts and set to build the system. Great article, by the way—the instructions were excellent. However, right at the start, I was stumped, with the MSI MPG X570 motherboard having both CPU PWR1 (eight pins) and CPU PWR2 (four pins) connectors, but the PSU (Corsair RM 550X) gave me the only one eight-pin connector that actually can be split in a nifty way into two separate four-pin connectors. So, I did a search on the problem and encountered some conflicting and occasionally passionate and opinionated advice from other DIY builders regarding this issue. I checked the manuals—there wasn't much there in terms of clarification or advice. According to the manual, both CPU PWR1 and CPU PWR 2 supply 12V.

Hence my question, and I believe others may like to read about it as well: What actually is the purpose of the CPU PWR2 connector, and what is the best way to connect a split 2x4-pin connector to CPU PWR1 and CPU PWR2 connectors on the motherboard?

–Piotr Kozlowski

STAFF WRITER, CHRISTIAN GUYTON, RESPONDS: Essentially, you don't need the additional four-pin connector. A single eight-pin CPU power connector provides sufficient power to the processor for the system to function normally—older motherboards may even just have a single four-pin connector. Most PSUs come with one eight-pin CPU power cable; this may or may not be split into two four-pin connectors.

Any additional connectors are for supplying more power to the CPU, typically for manual overclocking. Auto-overclocking functions (such as AMD's Ryzen Master software) work with just an eight-pin connector, because they adjust the maximum overclock to the voltage available. Many modern motherboards have either an extra four-pin or eight-pin connector for extreme overclocking.

We didn't build our budget system to be overclocked, so the additional four-pin connector on the MSI motherboard is superfluous. The RM550x is non-modular, so there's no way to provide the extra voltage without swapping out the PSU, and the Ryzen 5 3400G barely has any overclocking headroom anyway. Long story short: You can ignore that four-pin connector altogether.

[NOW ONLINE]

THE BEST GRAPHICS SETTINGS FOR MECHWARRIOR 5: MERCENARIES

MechWarrior 5: Mercenaries is a return to form for the series. Built by the same developers behind *MechWarrior Online,* Piranha Games, but with a change to Unreal Engine 4 in place of MWO's CryEngine, it's a brave new world. Our review (http://bit.ly/395tcOW) covers the design, so we're going to talk about performance and settings now.

We played the hell out of the original *MechWarrior* back in the day, in glorious 16-color EVGA graphics, with sound effects coming from an internal PC speaker. When we upgraded from an 8086 to a 386 processor, the slow and ponderous battles became far more exciting. We've thankfully moved beyond the era of game speed being linked to your PC's performance (mostly), but 30 years later, the core gameplay in *MechWarrior 5: Mercenaries* isn't radically different. The graphics meanwhile have improved tremendously. Our 16-year-old selves would have loved *MechWarrior 5: Mercenaries*, warts and all. Read the full article: https://bit.ly/2s8GSb7

Mac Pro Challenge

Maximum PC must go head to head with the Apple Mac Behemoth: the fully kitted out Mac Pro costs $53,799.

–Bob Renuart

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: As you know, we love a challenge, and nothing gets us going more than Apple's price gouging, so consider us in. Now, we can't promise to build a machine that grates cheese, or drops a grand on the monitor stand, but we reckon we can take on the core specifications just fine. Watch this space.

Reader Requests

I just renewed for a couple of years, so I thought I'd send you my suggestion for articles. I'd like to see something on the tech, selection, and review of 4K, 5K, and 8K monitors, as well as a companion article on the video cards required to support these monitors.

I'd also like to see more articles on cooling, and best practices to configure a PC (air and liquid). Things like when to use low versus high velocity fans, how many, where to best place, in versus out, etc. I thought the 2019 article was too general.

–John Reilly

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: We've been trying to get in a few of the higher resolution screens for a while, but haven't had much luck so far. Maybe we'll see more 8K panels soon, as that would help. We have looked at the Dell UP2715K, 5K panel already, finding the pixel pitch hard work for a 27-incher, but I like the idea of a general roundup, so will pencil this in for a future issue. The same goes for the cooling best practices—we'll cover this in more detail soon.

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$70
PSU	Corsair CX450 80+ White 450W	$50
Mobo	MSI B450M PRO-M2 V2	$75
CPU	AMD Ryzen 5 2600	$120
GPU	EVGA GeForce GTX 1660 Super Black 6GB NEW	$230
RAM	8GB (2x 4GB) Patriot Viper Steel Series @ 3,200MT/s NEW	$38
SSD	120GB Adata SU650 SATA III	$23
HDD	1TB Seagate Desktop ST1000DM003	$30
OS	Ubuntu Desktop Linux 18.04.3 LTS 64-bit	$15

Approximate Price: $651

IN A POST-SALE WORLD, keeping the prices low for this issue was difficult. There wasn't much to update in the budget build this time around, merely tweaking the setup in an effort to keep the price low, but maintain standards. To that end, we've swapped over to an EVGA GPU, more specifically the GTX 1660 Super Black, due to last month's Gigabyte offering no longer being on sale. Really, though, any 1660 Super (or a 1660 Ti if you can grab one on sale) is a good choice for an affordable PC build. The only other thing we changed was the memory, sticking with Patriot, but changing over from Viper 4 to the Viper Steel Series to keep our costs down. Despite that, the overall price for this build has risen by a few dollars; most of the components here are the cheapest good-quality parts available, and the prices only vary so much. We're sorry, dear reader, but that's the best we can do.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$85
PSU	500W EVGA 500 BR 80+ Bronze NEW	$58
Mobo	ASRock X570 Phantom Gaming 4	$140
CPU	AMD Ryzen 5 3600X	$240
Cooler	AMD Wraith Spire	N/A
GPU	XFX Radeon RX 5700 8GB	$330
RAM	16GB (2x 8GB) Patriot Viper 4 Blackout @ 3,200MT/s NEW	$65
SSD	500GB Sabrent Rocket M.2 PCIe SSD NEW	$110
HDD	1TB Seagate Desktop ST1000DM003	$30
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,158

UNLIKE THE BUDGET BUILD, we've managed to drop the price of the mid-range build slightly. A few price drops here, some new components there, and we've ended up saving 13 dollars on last issue's build. First, the EVGA BT power supply has been swapped for the BR variant of the same wattage, while we've taken some pointers from the budget build with the RAM; 16GB of Patriot's Viper 4 Blackout edition memory at 3,200MT/s. Remember to hop into the BIOS to adjust the memory settings, making sure your memory is running at full speed. Lastly, we've replaced the no-longer-on-sale FireCuda SSD with the 500GB Sabrent Rocket, which keeps PCIe Gen4 transfer speeds, but also comes with a chunky detachable heatsink. You can save a further 10 bucks by going for the version without the heatsink, but the ASRock mobo doesn't come with an integrated heat plate for M.2 drives.

UPGRADE OF THE MONTH

500GB SABRENT ROCKET M.2 PCIE SSD

Sabrent's Rocket SSD is one of the more affordable Gen4 M.2 drives available on the market at the moment. It also comes with one of the most detailed SSD heatsinks we've seen: a combination of semi-exposed copper heat coils within a single carved-out block of aluminum, topped with a heat spreader. The model with a heatsink only costs 10 bucks more, so we recommend it. The overall performance is as crazy-fast as we've come to expect from Gen4 SSDs, topping out at around 5,000MB/s in sequential write speeds. With 500GB capacity and a Phison memory controller, this drive is a steal right now. **$110, http://sabrent.com**

© SABRENT

NO, WE'RE NOT PUTTING a third-generation Threadripper in this PC. Yet. We'll get there, but right now the pricing is simply too steep to justify it; new sTRX4 motherboards are also monstrously expensive, so upgrading this system to the third gen would throw a comfortable thousand dollars or more on the overall price. Second-gen Threadrippers, such as the 2950X, are great value right now, so we just don't think it's worth the asking price yet.

Even without making that upgrade jump, the price of this build has still risen by over 100 bucks this month. A distinct lack of sales (and our insistence on keeping a Gen4 M.2 SSD for future upgrade potential) means there were few opportunities to make savings. We changed out the GPU for a comparable MSI model, and upgraded our motherboard to the Asus Prime X399-A.

Sticking with 32GB of RAM, we've gone back to G.Skill's Sniper X memory at 3,600MT/s, ensuring we have great memory support for our Threadripper CPU. The last change we made was in service to M.2 Gen4; we want this build to be ready for a Threadripper 3960X, and that means ultra-fast SSD transfer speeds. To that end, we've replaced the XPG SSD with Gigabyte's weighty Aorus SSD, as the XPG drive is no longer on sale. The Aorus SSD was one of the first Gen4 M.2 drives on the market, and its performance still holds up (even if the heatsink is a pain to remove).

For more of our component recommendations, visit www.pcgamer.com/hardware/buying-guides/

INGREDIENTS

PART		PRICE
Case	NZXT H700i	$175
PSU	850W Corsair RM850 80+ GOLD	$128
Mobo	Asus Prime X399-A **NEW**	$300
CPU	AMD Threadripper 2950X	$680
Cooler	Cooler Master MasterLiquid ML360 RGB 360mm AIO	$140
GPU	MSI GeForce RTX 2080 Super Ventus 8GB **NEW**	$720
RAM	32GB (2x 16GB) G.Skill Sniper X Series @ 3,600MT/s **NEW**	$137
SSD	1TB Gigabyte Aorus Gen4 NVMe M.2 SSD **NEW**	$210
HDD	2x 3TB Seagate BarraCuda Compute	$160
OS	Windows 10 Home 64-bit OEM	$100
Approximate Price:		**$2,750**

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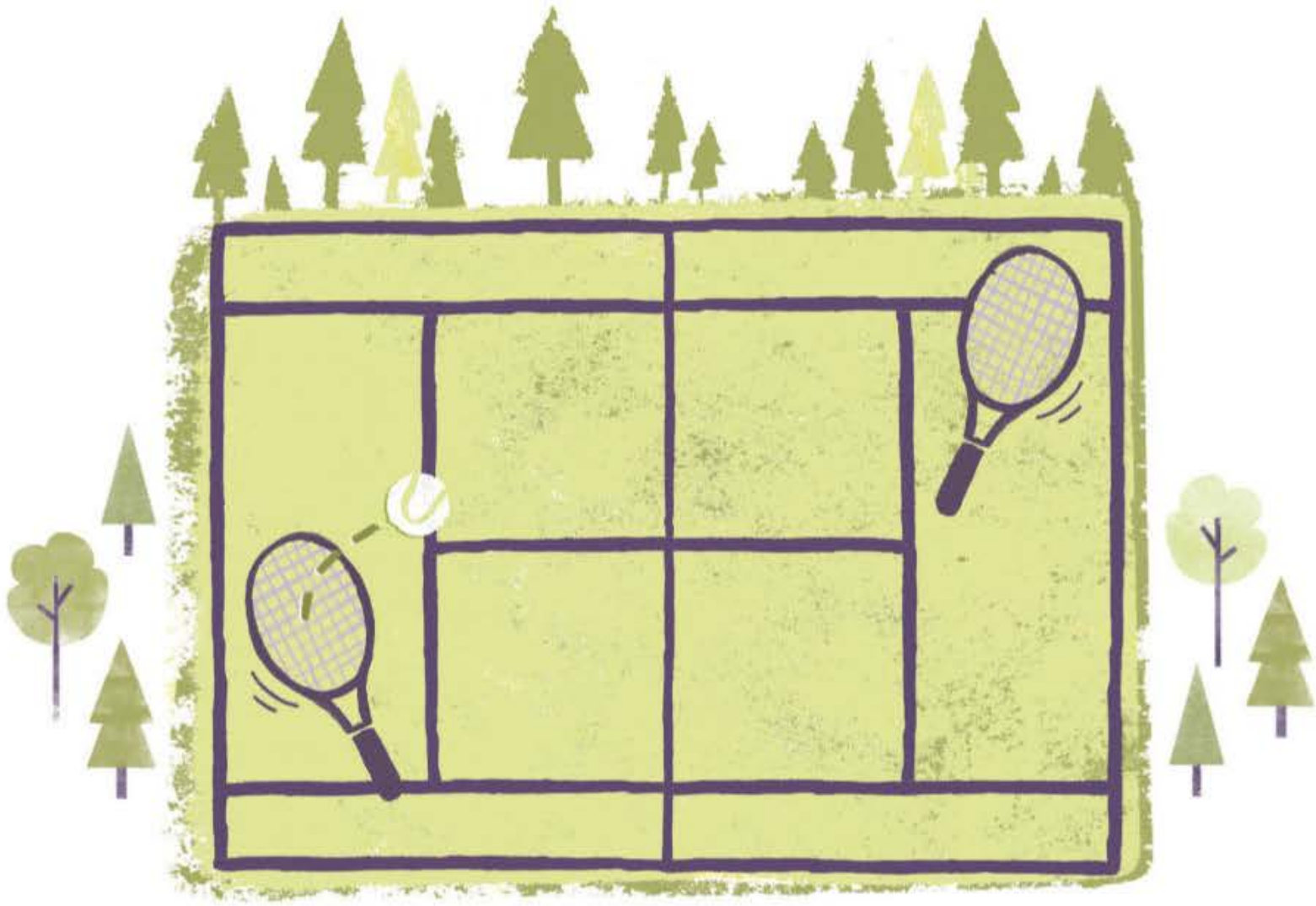

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